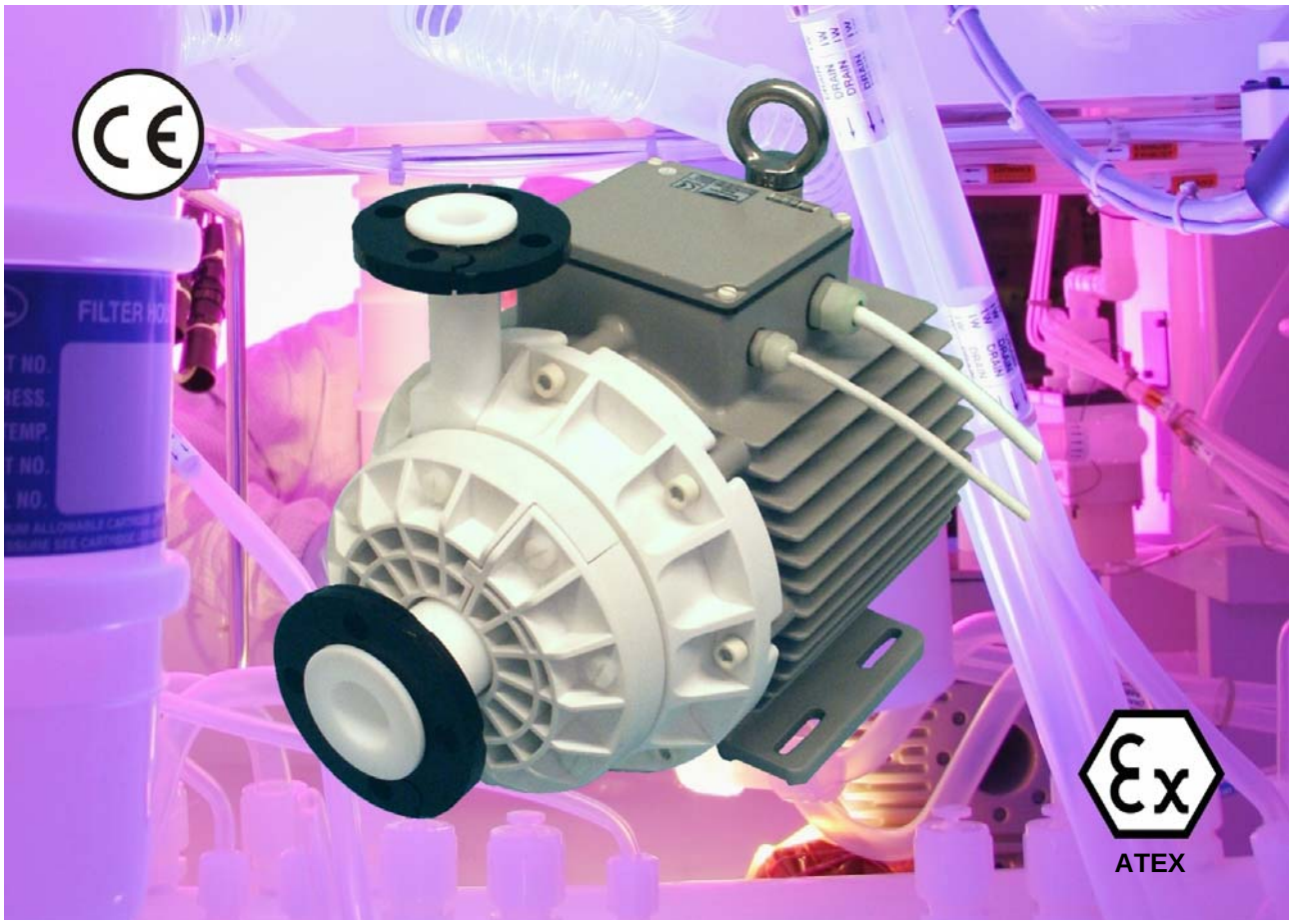
BPS-4000

6.3 bar (91 psi)
280 liters/min (74 gallons/min)

USER MANUAL



This manual contains information necessary for the safe and proper use of the *BPS-4000*. Included are specifications for the standard configurations of the pump system and instructions regarding its use, installation, operation, adjustment, inspection and maintenance. For special configurations of the pump system refer to accompanying information. Please familiarize yourself with the contents of the manual to ensure the safe and effective use of this product. After reading this manual, please store the manual where the personnel responsible for operating the pump system can readily refer to it at any time.

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1 Safety Precautions

CAUTION

Do not under any circumstances open the controller or motor. Levitronix does not assume responsibility for any damage, which occurs under such circumstances.

CAUTION

High magnetic field strength of pump impeller.

The pump system contains a rotor magnet with high field strength. This may alter or damage the calibration of sensitive electronic devices and measuring instruments in the immediate surroundings. Keep at a safe distance from the rotor, computers, monitors and all magnetic data storage media (e.g. disks, credit cards, audio, video tapes etc.)

⚠ WARNING

Hazardous voltage may be present.

The controller must be grounded and placed in a spill protected environment. Do not under any circumstances open the powered controller.

⚠ WARNING

High magnetic field strength of pump impeller.

The pump system contains a rotor magnet with high field strength. Pace maker may be influenced and magnetic forces may lead to contusions. Keep distance to pace makers and handle impeller with care.

⚠ WARNING

TOXIC CHEMICALS may be present.

When using the system to pump chemicals skin contact and toxic gases may be hazardous to your health. Wear safety gloves and other appropriate safety equipment.

⚠ WARNING

Motors for ATEX applications: only specific types of motors LPM-4000 are classified for the use in ATEX Zone 2 classified locations. Refer to the corresponding section in the manual.

2 Specifications

2.1 Specification of Components

Figure 1 shows the main system components (motor, controllers, and pump head) and *Figure 2* illustrates the accessories.

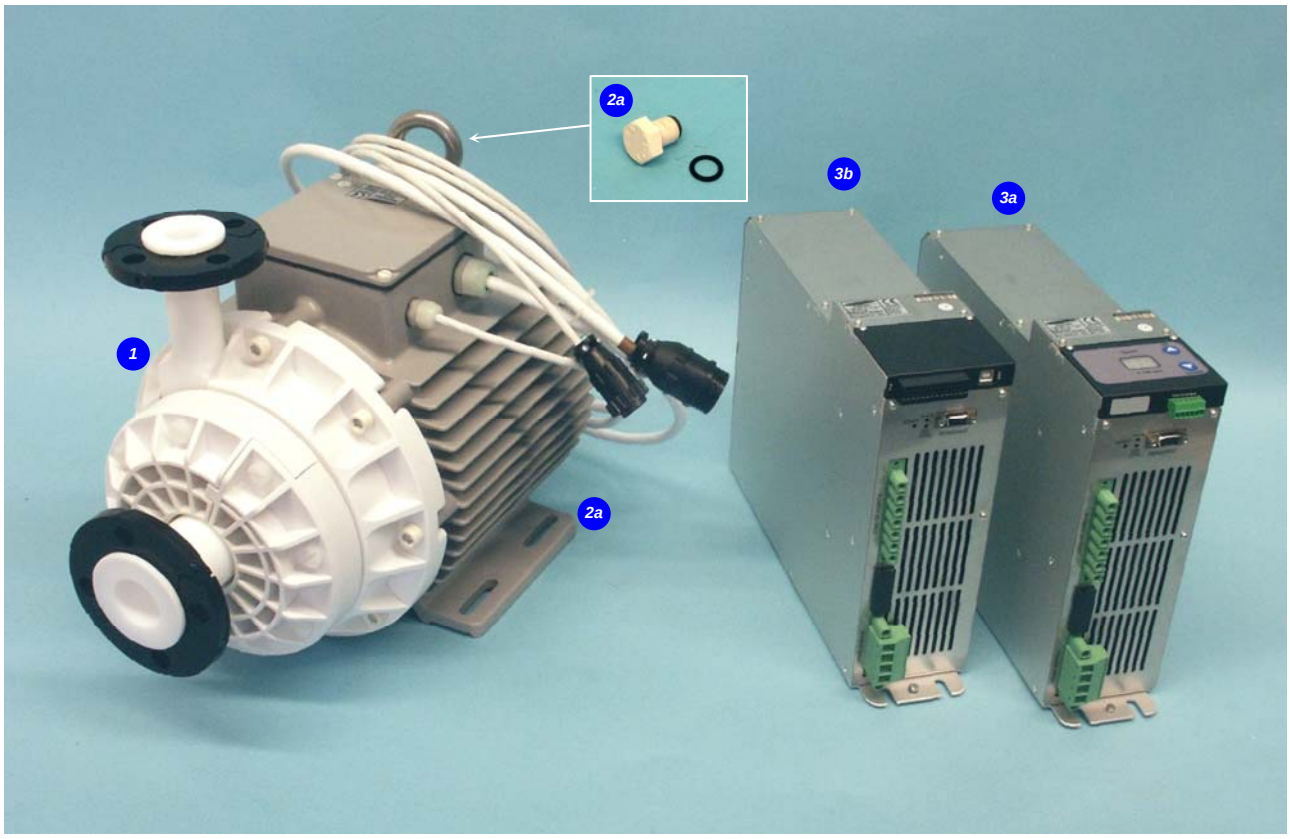


Figure 1: Pump system BPS-4000 with standard components

Figure 2: Pump System Accessories

System Name	Article #	Pump-head	Motor	Controller	Note
BPS-4000.1	100-90372	LPP-4000.1	LPM-4000.2	LPC-4000.1	Adaptor/Extension (0.5 - 10m) cables according to Table 4 (position 4a and 4b) have to be ordered as separate article with specified length.
BPS-4000.2	100-90373			LPC-4000.2	
BPS-4000.16 (ATEX)	100-90436		LPM-4000.8 (ATEX)	LPC-4000.1	Adaptor/Extension (0.5 - 10m) cables according to Table 4 (Position 5a and 5b) have to be ordered as separate article with specified length. ATEX Cable Sealing System can be ordered according to Table 4 (Position 8)
BPS-4000.17 (ATEX)	100-90438			LPC-4000.2	

Table 1: Standard system configurations

Pos.	Component	Article Name	Article #	Characteristics	Value / Feature
1a	Pump-Head	LPP-4000.1	100-90294	Impeller / Pump Housing Reinforcing Housing Sealing Ring Fittings	ECTFE / PTFE (wet parts) PP + GF30 Kalrez® perfluoroelastomer [1] ANSI Flange 1.5" Inlet / 1" Outlet
				Max. Flow Max. Diff.-Pressure Max. Viscosity / Density	280 liters/min / 74 gallons/min 6.3 bar / 91 psi 30 cP / 1.8 g/cm^3
				Max. Liquid Temp.	Full performance: 70 °C / 158 °F Limited performance: 70-90 °C / 158-194 °F (see Figure 6
				Max. Static Pressure	8.2 bar / 119 psi @ 25 °C / 77 °F liquid temp. (mounted on motor)
				Weight	5 kg / 11 lb
2a	Motor	LPM-4000.2	100-10043	Housing	- ETFE (chemical resistant) coated Aluminum - waterproofed (IP67 without connectors) - protective screw (SS with PTFE coating) for mounting thread included (see Figure 1, Pos. 2a)
				Cable / Connectors	2x 3m cables with FEP jacket / 2x circular (AMP types)
				Weight	35 kg / 77 lb
2b	Motor (ATEX certified)	LPM-4000.8	100-10048	ATEX Marking	CE Ex II 3G Ex nA T5 CE Ex II 3D Ex tD A22 IP67 T100°C
				Cable / Connectors	2x 3m cables with FEP jacket / 2x circular (M23, IP67)
3a	Standalone Controller (User Panel)	LPC-4000.1	100-30012 (Controller with power supply and Enable connector incl. in 100-90370)	Voltage	1 x 200-240 V AC ±10% / 1 x 22 – 18.4 A ±10% 3 x 200-240 V AC ±10% / 3 x 10.9 – 9.1 A ±10%
				Electrical Power	4 kW
				Weight	6.5 kg / 14.3 lb
				Interfaces for Standalone Controller	Panel to set speed (automatic storage on internal EEPROM)
					PLC with: 1x analog input ("Speed") 4 - 20 mA; 1x digital input ("Enable") 0 - 24 V (optocoupler); 1x digital output ("Status") 0 - 24 V (relais)
3b	Extended Controller (PLC and USB)	LPC-4000.2	100-30013 (Controller with power supply and PLC connector incl. in 100-90371)	Interfaces for Extended Controller	PLC with: - up to 4 digital inputs 0 - 24V (optocoupler); - up to 4 digital outputs 0 - 24 V (relais); - up to 2 analog inputs 4 - 20mA; - up to 2 analog inputs 0 – 10 V; - up to 2 analog outputs 0 – 5 V
					USB interface (for service and system monitoring)

Table 2: Specification of standard components

[1] Kalrez® is a registered trademark of DuPont Dow Elastomers

Pos.	Component	Article Name		Article #		Characteristics	Value / Feature
		Sensor Cable	Power Cable	Sensor	Power		
4a 4b	Extension Adaptor Cable for Sensor (a) and Power (b)	MCAS-600.1-05 (0.5m) MCAS-600.1-30 (3m) MCAS-600.1-50 (5m) MCAS-600.1-70 (7m) MCAS-600.1-100 (10m)	MCAP-4000.1-05 MCAP-4000.1-30 MCAP-4000.1-50 MCAP-4000.1-70 MCAP-4000.1-100	190-10122 190-10123 190-10124 190-10101 190-10125	190-10172 190-10173 190-10174 190-10175 190-10176	Jacket Material Connector Types Connector Material	PVC Circular AMP to D-SUB Plastics (PA)
5a 5b	Extension Adaptor Cable for Sensor (a) and Power (b) Wires	MCAS-600.3-05 (0.5m) MCAS-600.3-30 (3m) MCAS-600.3-50 (5m) MCAS-600.3-70 (7m) MCAS-600.3-100 (10m)	MCAP-4000.2-05 MCAP-4000.2-30 MCAP-4000.2-50 MCAP-4000.2-70 MCAP-4000.2-100	190-10158 190-10159 190-10130 190-10160 190-10161	190-10180 190-10181 190-10182 190-10183 190-10184	Jacket Material Connector Types Connector Material	PVC Circular M23 (IP-67) to D-SUB Metallic – Nickel coated

Table 3: Specification of adaptor/extension cables

Pos.	Component	Article Name	Article #	Characteristics	Value / Feature	
6a	Air Cooling Module	ACM-4000.1	190-10177	Material / Connection Port	PP / NPT 1/2"	
				Air Pressure	~1 - 3 bar (14 – 43 psi)	
6b	Air Cooling Module	ACM-4000.3	190-10190	Material	PP-EL-S with conductive additive for operation with ATEX motor	
7	Fan Cooling Module	FCM-4000.1	190-10178	Housing Material Cable Supply Spec. / IP Rating	PP (+ 40% Talkum) PVC, 6m, open-end wires 20.4 – 27.6 VDC, 31.2 W, 1.3 A / IP-55	
8 (a - d)	Impeller Exchange Kit	IEK-4000.1	100-90522	Impeller LPI-4000.1 (a) O-Ring (b) Pump Casing Screws (c) Pump Motor Screws (d)	ECTFE O-Ring, Kalrez®, 113.9 x 3.53 8pcs M10x35, PVDF 8pcs M10x35, Stainless Steel with PTFE coating	
9 (a – f)	ATEX Cable Sealing System	ACS-A.1 (Roxtec)	100-90292	Sleeve (a) and Gasket (b) Frame (c) 2x Cable Module (d)	Stainless Steel and EPDM Roxylon (EPDM rubber) Roxylon (EPDM rubber)	Note: Lubricant (e) and measurement plates (f) are included.

Table 4: Specification of accessories

2.2 Standard System Configurations

2.2.1 Stand-Alone System Configuration

The stand-alone configuration of the *BPS-4000* pump system (see *Figure 3*) consists of a controller with an integrated user panel to set the speed manually. The speed is automatically stored in the internal EEPROM of the controller. As an option, the speed can also be set with an analogue signal.

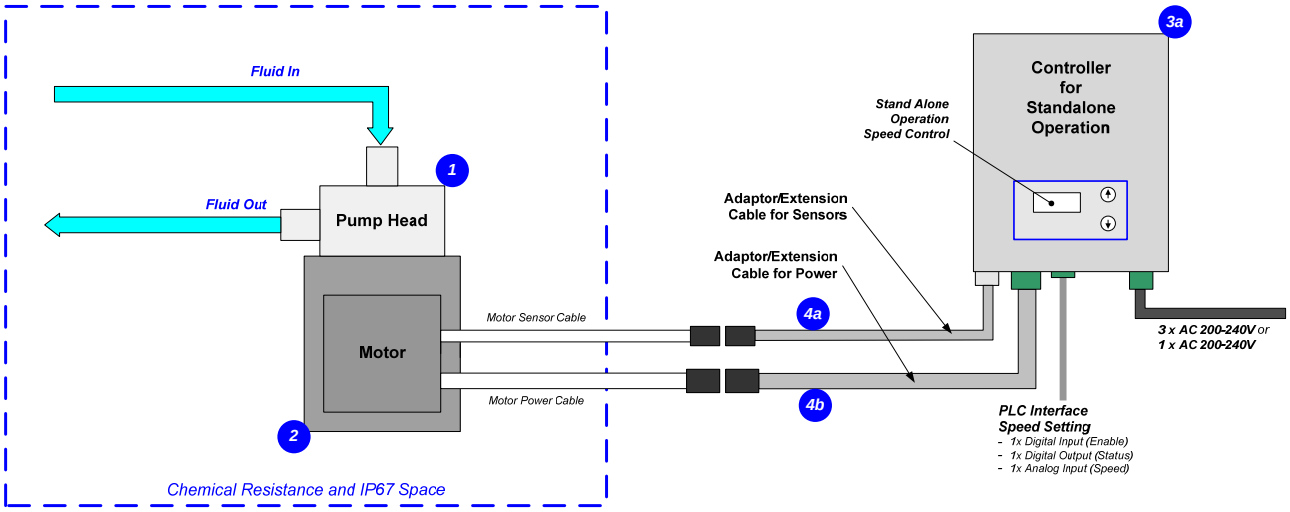


Figure 3: System configuration for standalone operation *(Speed setting with integrated user panel)*

2.2.2 Extended System Configuration

The extended version of the *BPS-4000* pump system (*Figure 4*) consists of a controller with an extended PLC interface. This allows setting the speed by an external signal (see specification of *Position 3b* in *Table 2*) and enables precise closed-loop flow or pressure control in connection with either a flow or a pressure sensor. A USB interface allows communication with a PC in connection with the Levitronix® Service Software. Hence parameterization, firmware updates and failure analysis are possible.

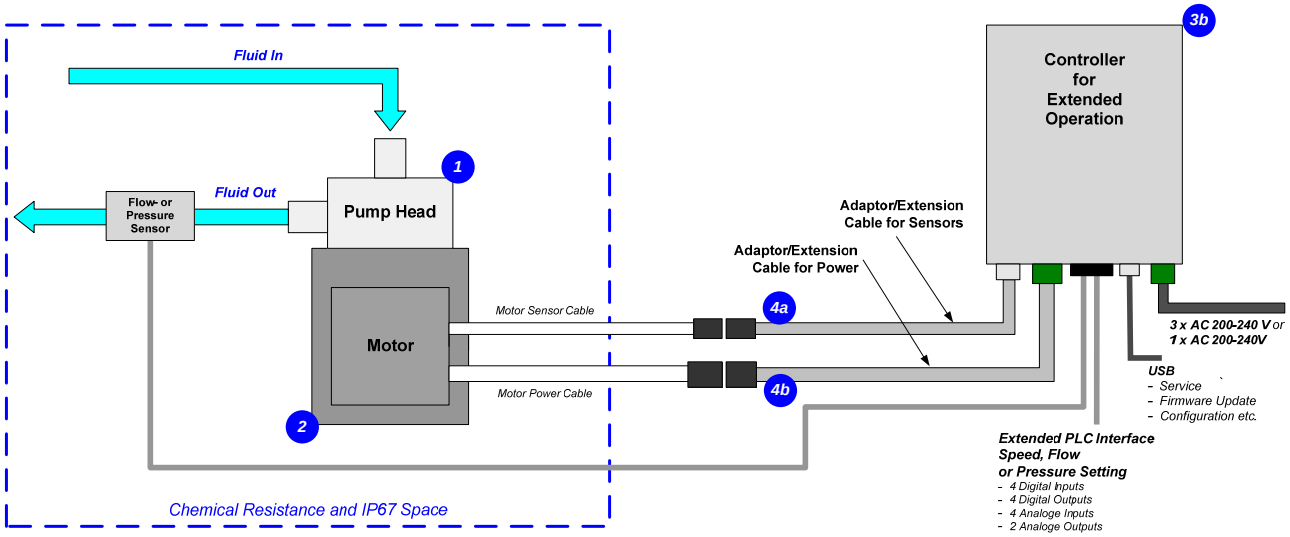


Figure 4: Extended operation (flow or pressure control) with extended controller

2.2.3 ATEX System Configuration

Together with the standard pump-head and controllers an ATEX certified motor allows installation of motor and pump-head within an ATEX Zone 2 area (see *Figure 5*). The ATEX motor (*Pos. 2b* in *Table 2*) comes delivered with special connectors and according extension cables (*Pos. 5a* and *5b* in Table *4*). One option to lead the cables outside of the ATEX area is an ATEX certified cable sealing system as listed in *Table 4* (see *Pos. 9*) and shown in *Figure 2.*

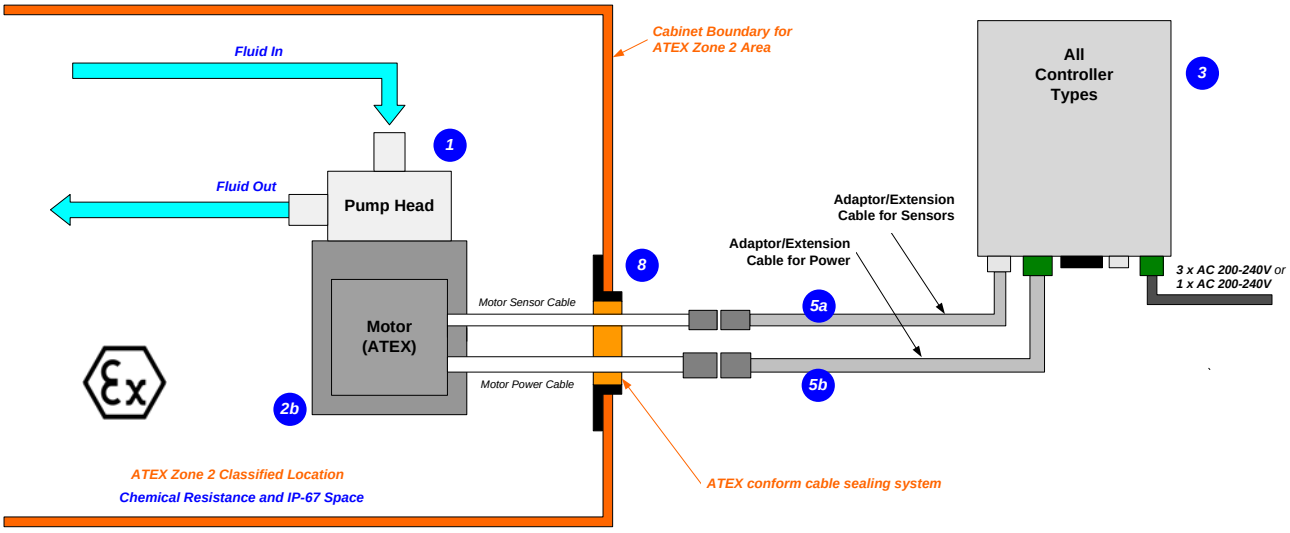


Figure 5: System configuration for ATEX applications

2.3 Pressure-Flow Curves

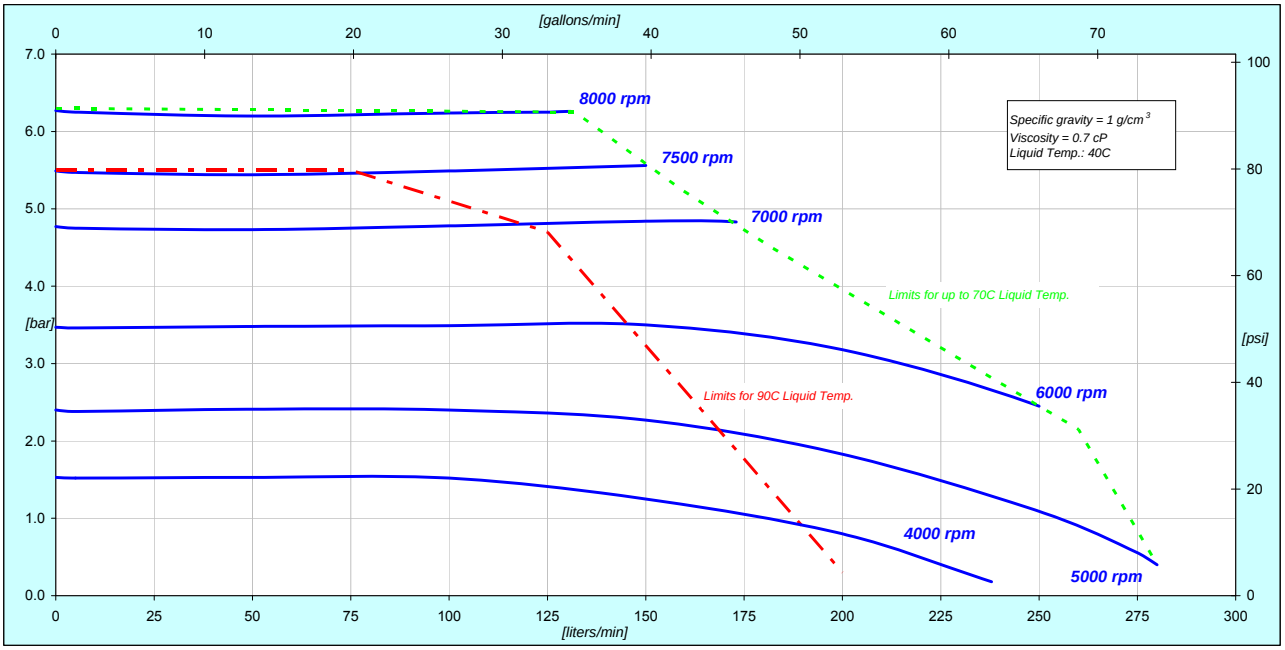


Figure 6: Pressure/flow rate charts for aqueous liquids
(Measured with pump-head LPP-4000.1)

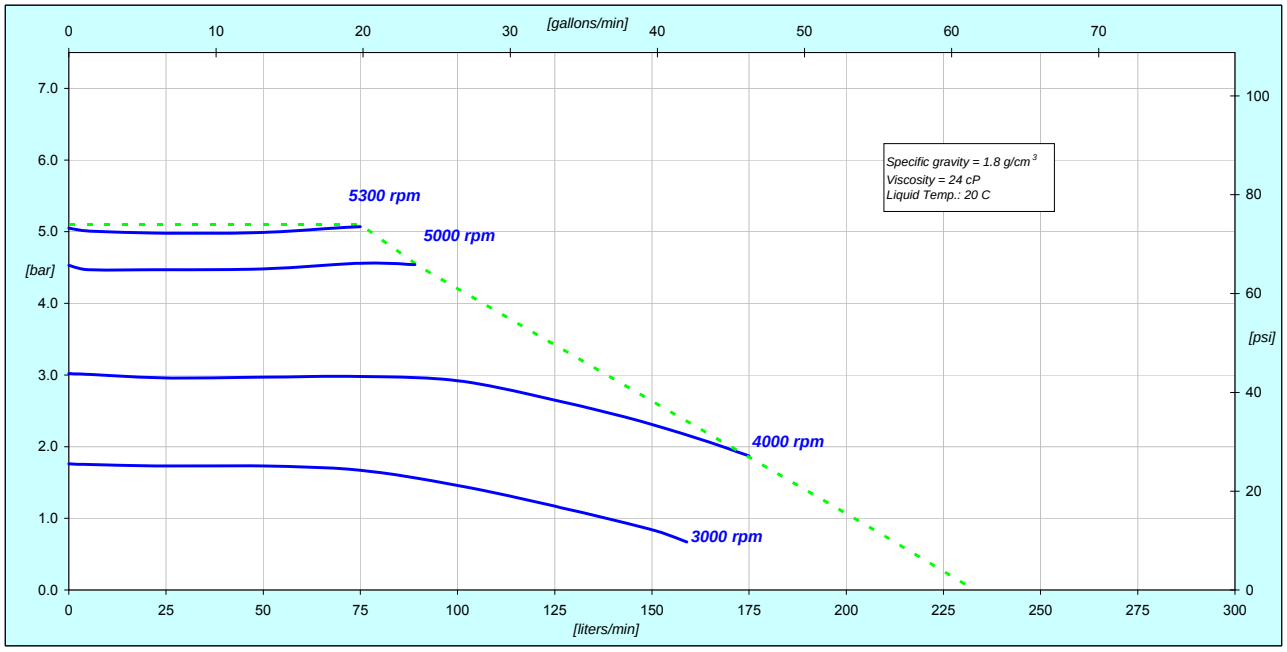


Figure 7: Pressure/flow rate charts for high density and viscosity liquids
(Measured with pump-head LPP-4000.1)

2.4 NPSHr Curves

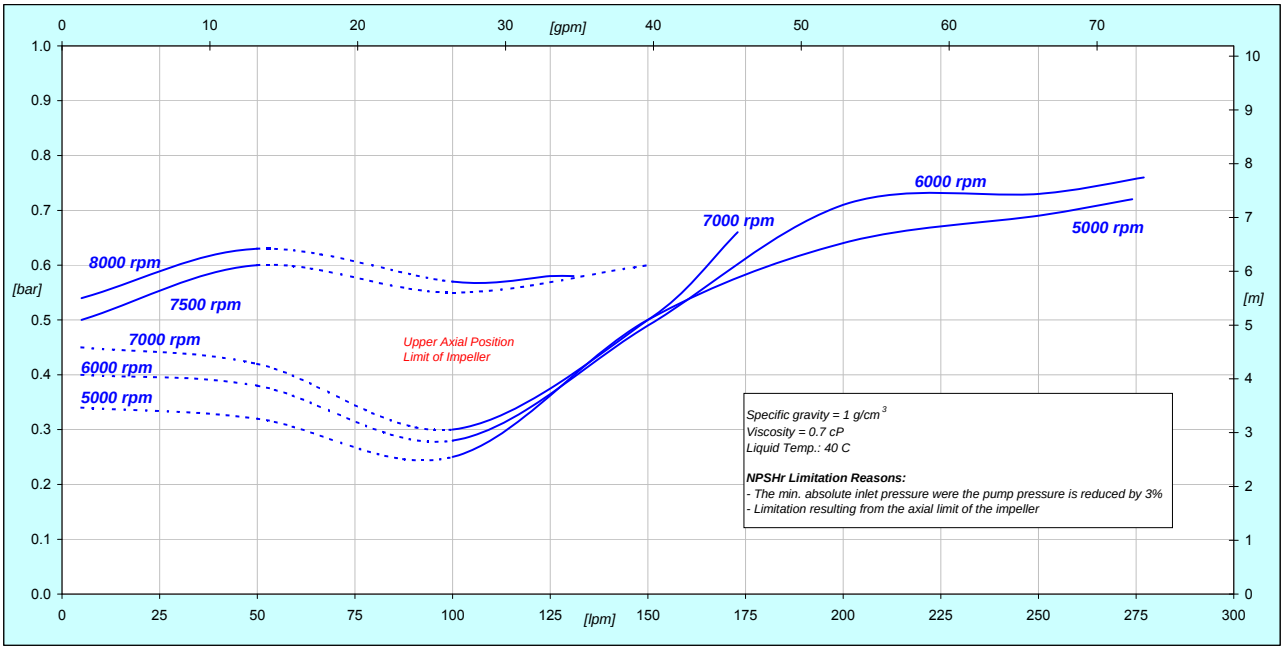


Figure 8: NPSHr curves
(Measured with pump-head LPP-4000.1)

2.5 General Environmental Conditions

Usage	Indoor (motor with pump head can be placed outdoor)
Altitude	Up to 2000m
Operating ambient temperature	0 to 40ºC
Storage ambient temperature	-20 to 80ºC
Operating humidity range (relative humidity)	15 – 95% (non condensing)
Storage humidity range (relative humidity)	15 – 95% (non condensing)
AC supply fluctuations	± 10% of nominal voltage
Transient over-voltages typically present on the mains supply	Surge immunity according to EN 61000-4-5
Pollution degree	2

Table 5: Environmental conditions for pump system

2.6 Basic Dimensions of Main Components

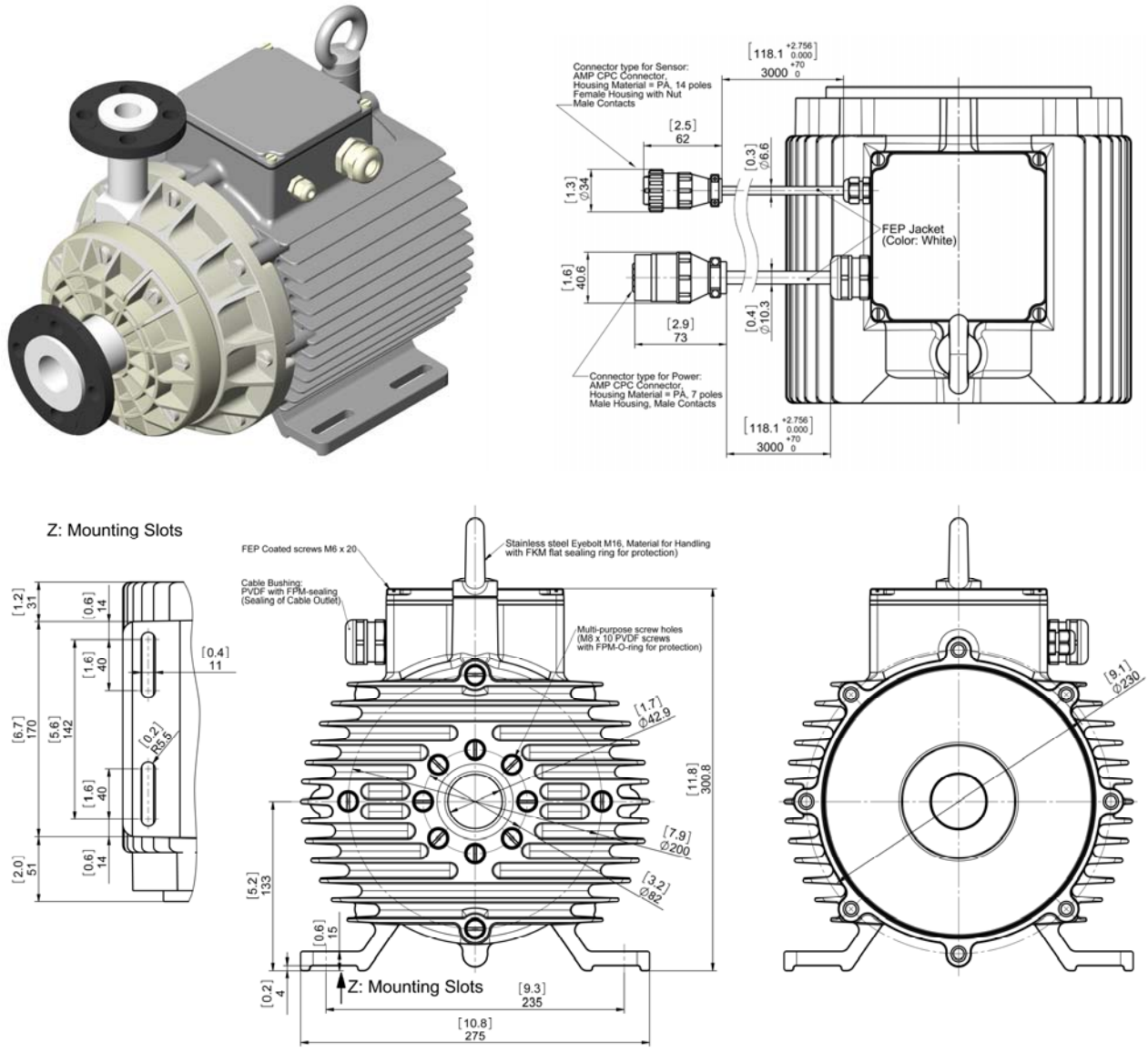

Connector type for Sensor:
AMP CPC Connector,
Housing Material = PA, 14 poles
Female Housing with Nut
Male Contacts
FEP Jacket
(Color: White)
Connector type for Power:
AMP CPC Connector,
Housing Material = PA, 7 poles
Male Housing, Male Contacts
Z: Mounting Slots
FEP Coated screws M6 x 20
Cable Bushing:
PVDF with FPM-sealing
(Sealing of Cable Outlet)
Stainless steel Eyebolt M16, Material for Handling
with FKM flat sealing ring for protection)
Multi-purpose screw holes
(M8 x 10 PVDF screws
with FPM-O-ring for protection)
Z: Mounting Slots

Figure 9: Basic dimensions (in mm and [inch]) of LPM-4000.2 motor

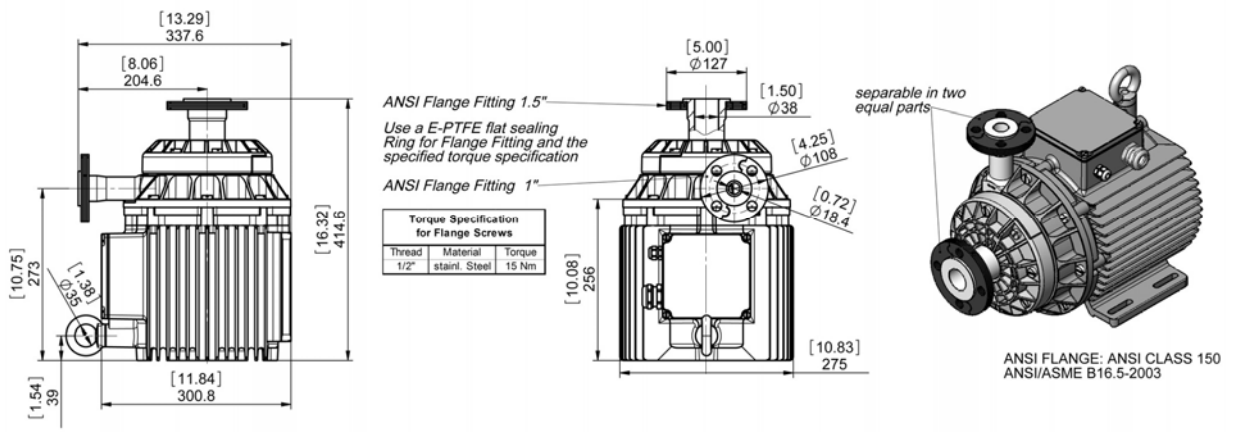


Figure 10: Basic dimensions (in mm and [inch]) of LPM-4000.2 motor with LPP-4000.1 pump head
(for other configurations refer to according drawings)

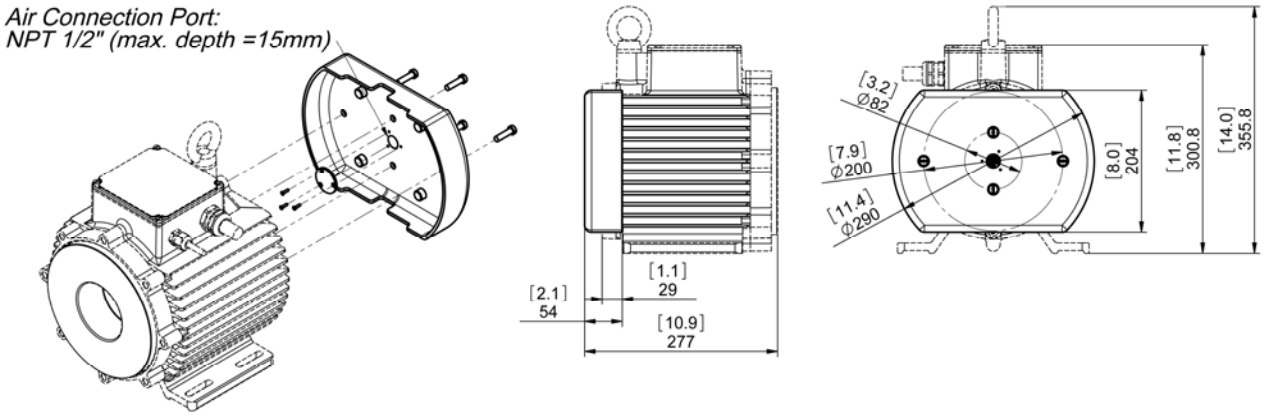


Figure 11: Basic dimensions (in mm and [inch]) LPM-4000 motor with ACM-4000.1 & 3 Air Cooling Module

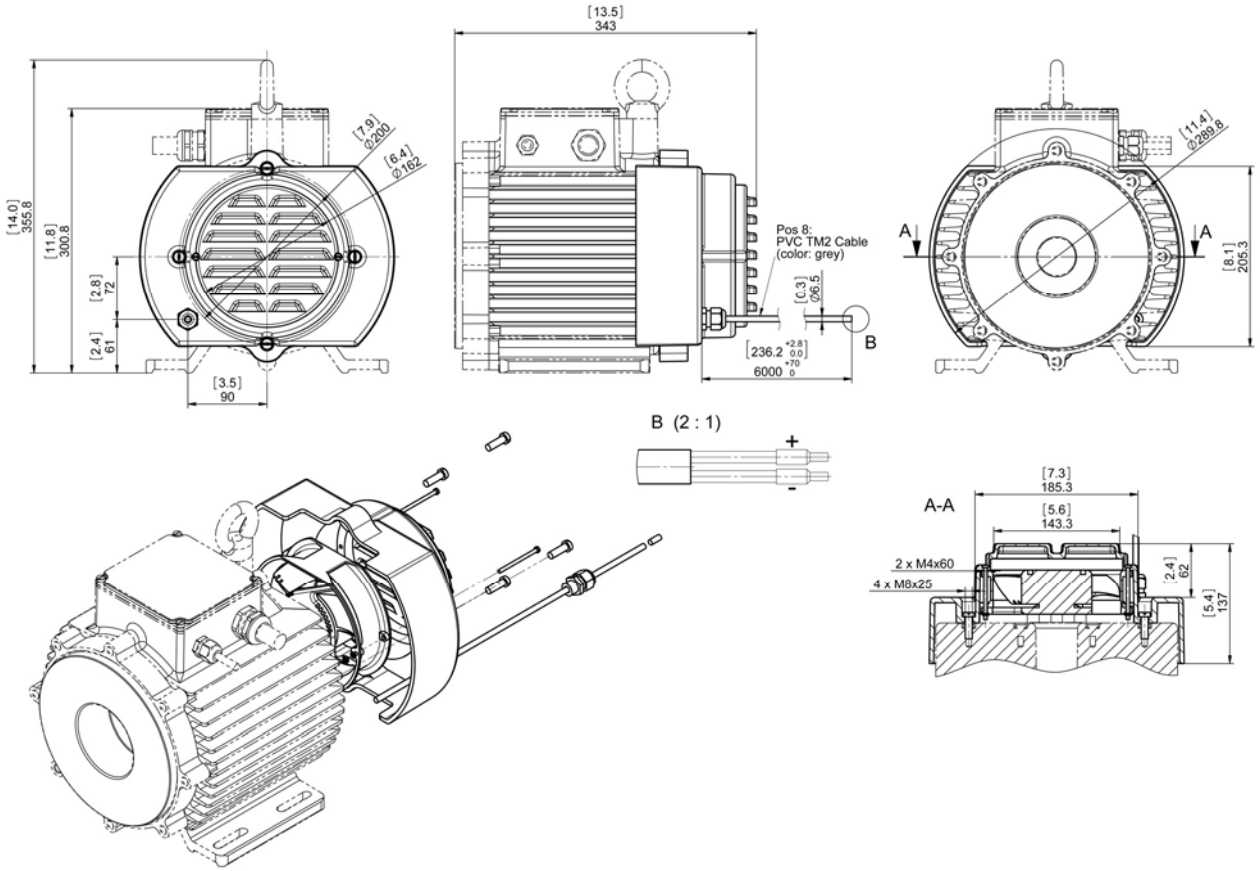


Figure 12: Basic dimensions (in mm and [inch]) LPM-4000 motor with FCM-4000.1 Fan Cooling Module

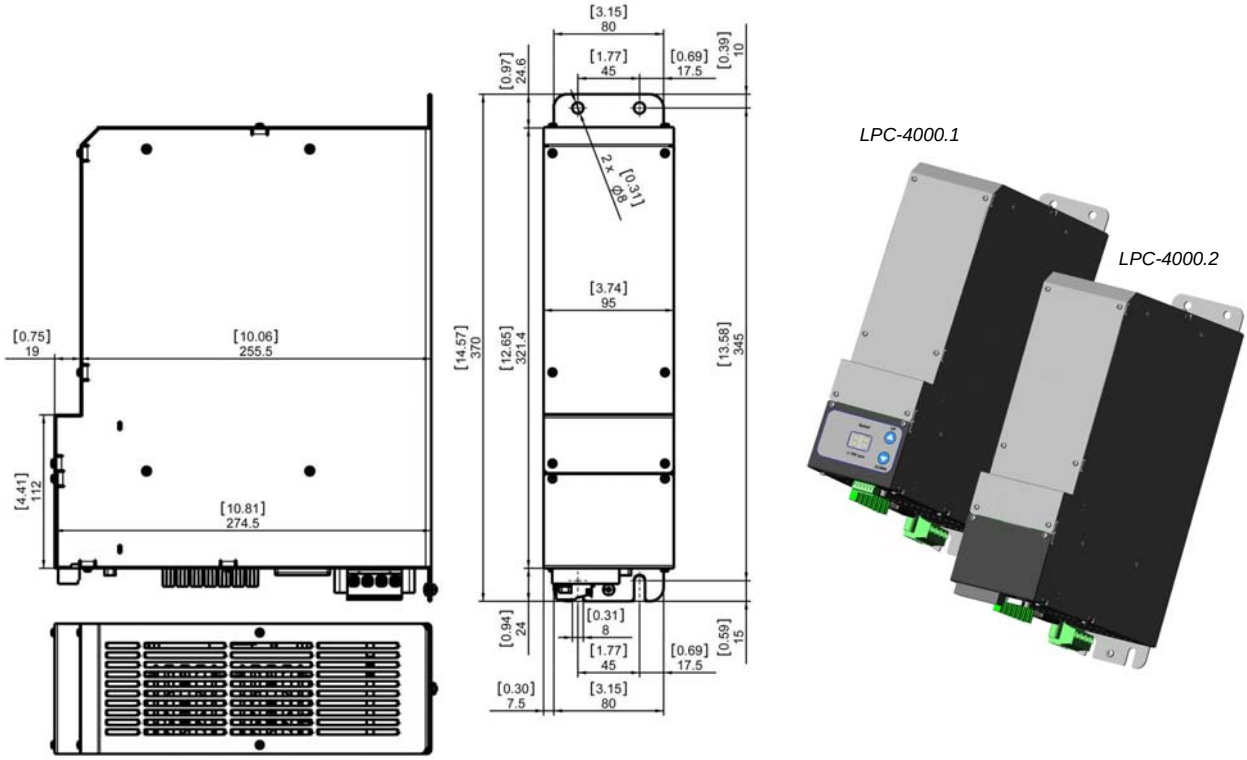


Figure 13: Basic dimensions (in mm and [inch]) of LPC-4000.1/2 controllers

3 Engineering Information

3.1 Sealing and Material Concept

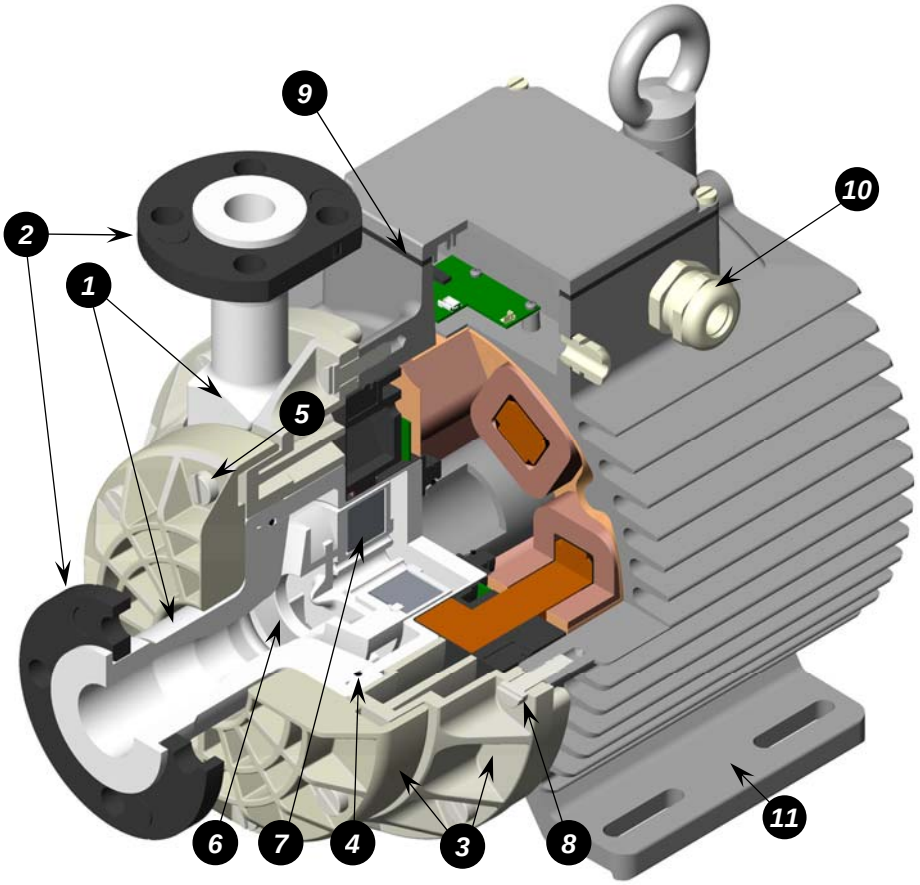


Figure 14: Sealing and material concept

System Component	Item		Materials
	No	Description	
Pump-Head *LPP-4000.1*	1	Pump casing (lid and bottom)	PTFE
	2	ANSI Flange rings 1.5” Inlet / 1” Outlet	PFA coated stainless steel
	3	Pump Adapter and Fixation Ring	PP (+ GF 30%)
	4	Static sealing O-ring of pump casing	Kalrez
	5	8 screws for pump casing	PVDF
	6	Impeller LPI-4000.1	ECTFE
	7	Rotor magnet	Rare-earth material
	8	8 screws for pump/motor mounting	PTFE coated stainless steel screws
Motor *LPM-4000.2*	9	Flat gasket for motor housing	FPM (= FKM)
	10	Cable bushing	PVDF, cable jacket is FEP
	11	Motor housing	ETFE coating, waterproof (IP-67) Coils and electromagnetic circuit potted with an epoxy compound (UL94 V0).

Table 6: Materials used in the LPM-4000.2 motor and LPP-4000.1 pump head

3.2 Power Consumption

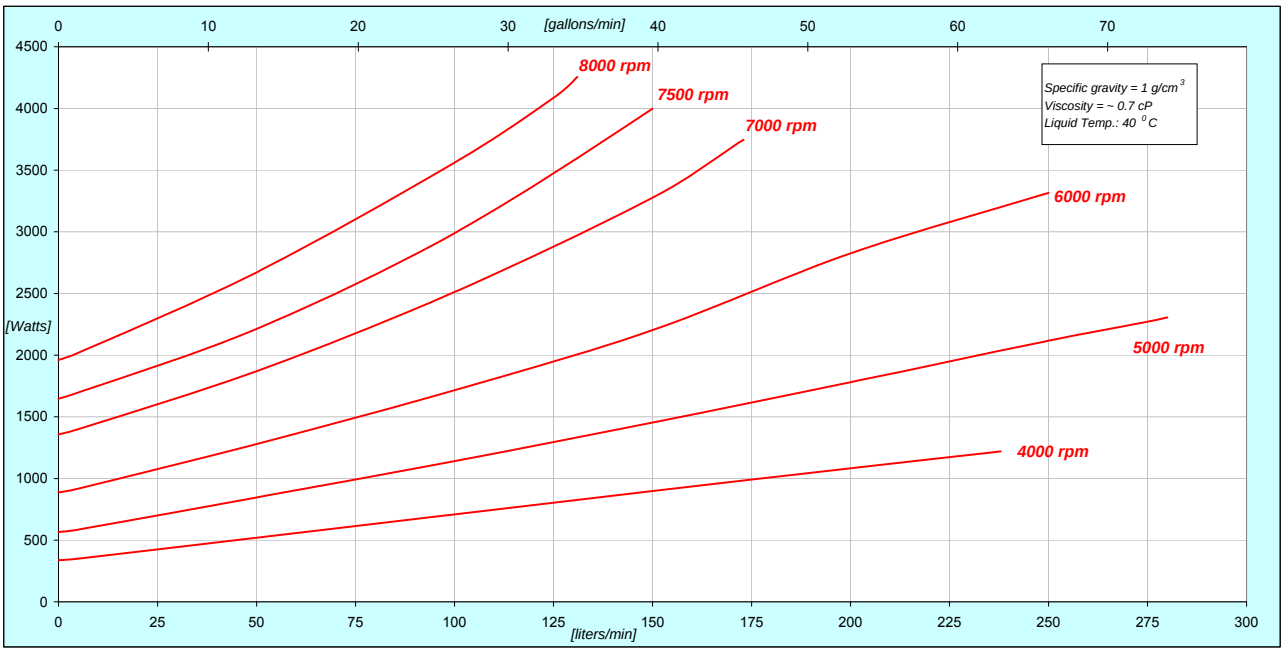


Figure 15: Electrical power consumption for aqueous liquids
(Controller LPC-4000.x with pump-head LPP-4000.1)

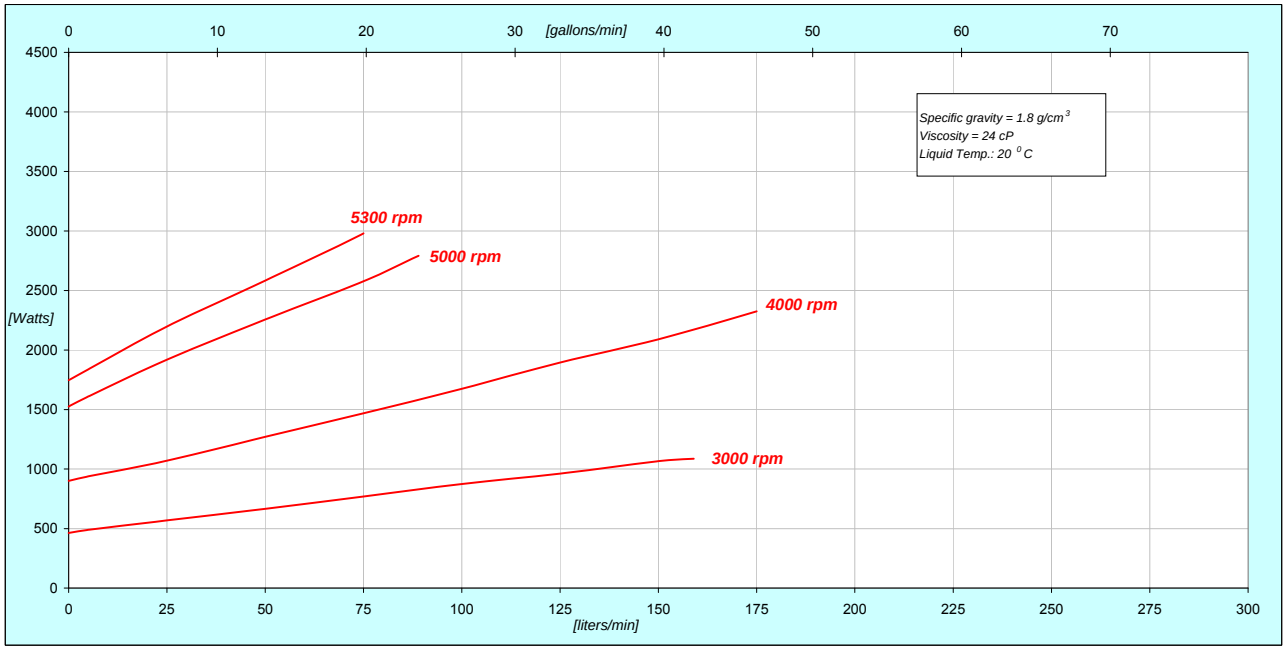


Figure 16: Electrical power consumption for higher density/viscosity liquids
(Controller LPC-4000.x with pump-head LPP-4000.1)

3.3 Temperature Monitoring

To avoid overheating of the system, the controller and motor temperatures are monitored. If the controller temperature exceeds *70°C (158°F)* or the motor temperature *90°C (194°F)* for a duration of more than 10 minutes, the system goes into an error state and the pump stops. At *80°C (176 F)* controller temperature or *100°C (212°F)* motor temperature, the system stops immediately.

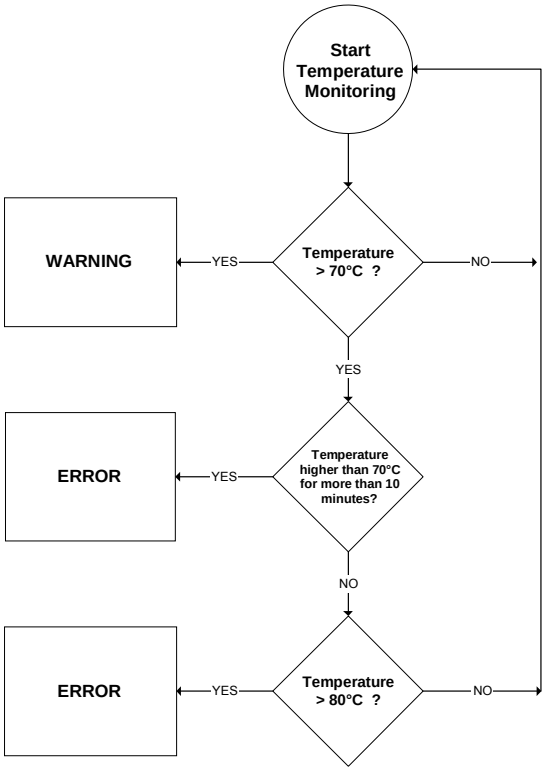


Figure 17: Controller temp. monitoring

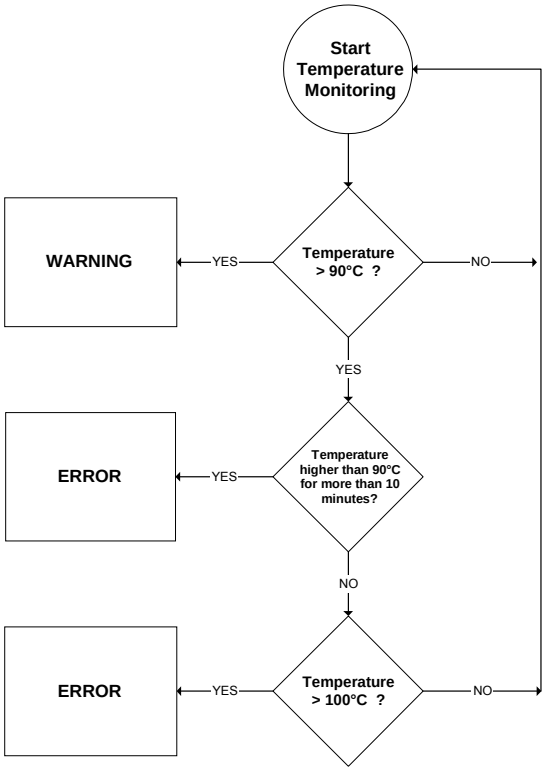


Figure 18: Motor temp. monitoring

3.4 Thermal Management

3.4.1 Motor Temperature

The motor temperature depends on the ambient and liquid temperature, as well as on the hydraulic operation point and the characteristics (viscosity and density) of the liquid. *Figure 19* illustrates the temperature characteristics of the motor depending on these parameters. For higher liquid temperatures, and hydraulic operating points active cooling is recommended for example with the *Air Cooling Module ACM-4000.1* (see *Figure 21*, *Table 4, Figure 11*) or the *Fan Cooling Module FCM-4000.1* (see *Figure 20*, *Table 4, Figure 12*).

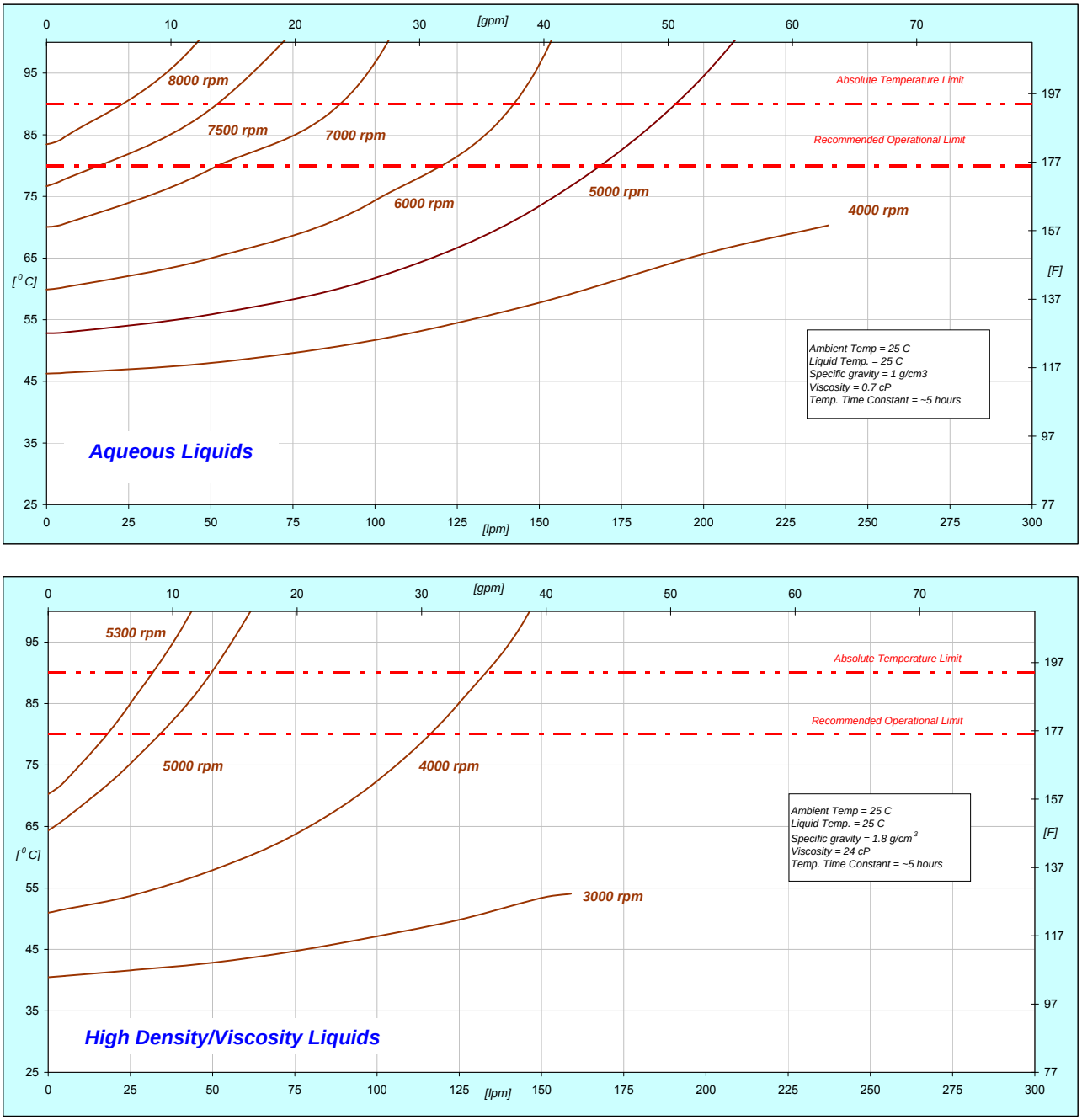
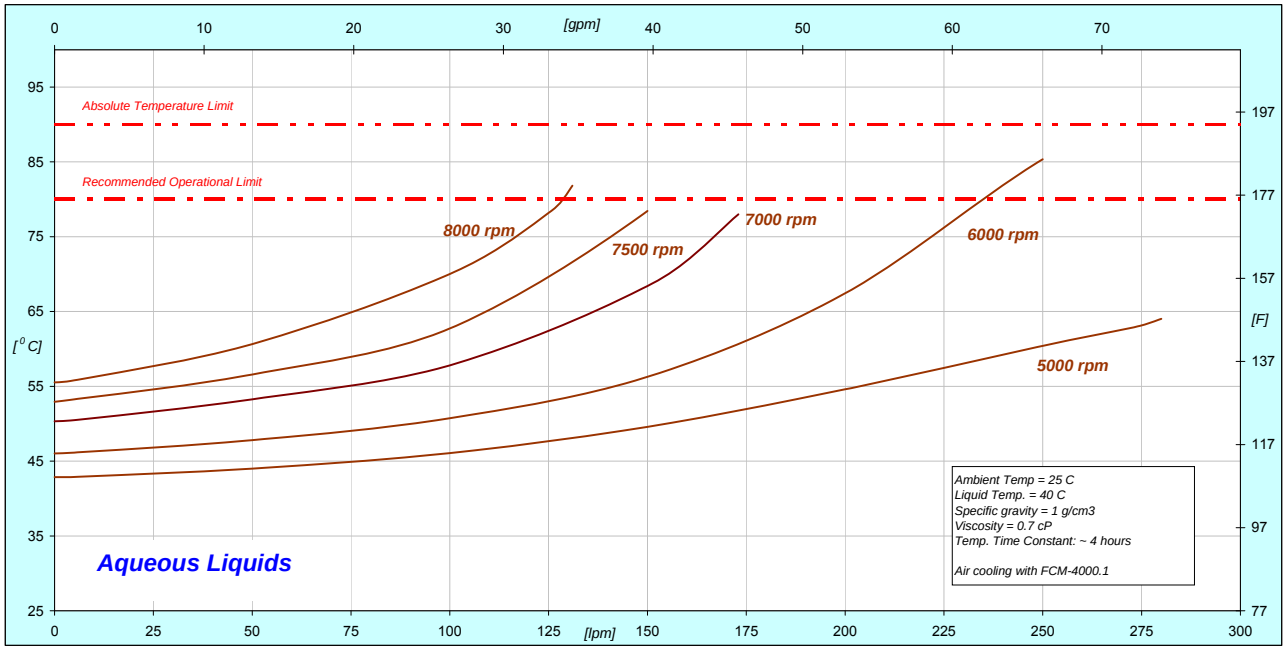


Figure 19: Temperature curves for the LPM-4000.2 motor @ 25 C liquid temperature
(Pumping with pump head LPP-4000.1, temperature is measured inside of the motor, temperature of housing and sensor electronics is significantly below this temperature)



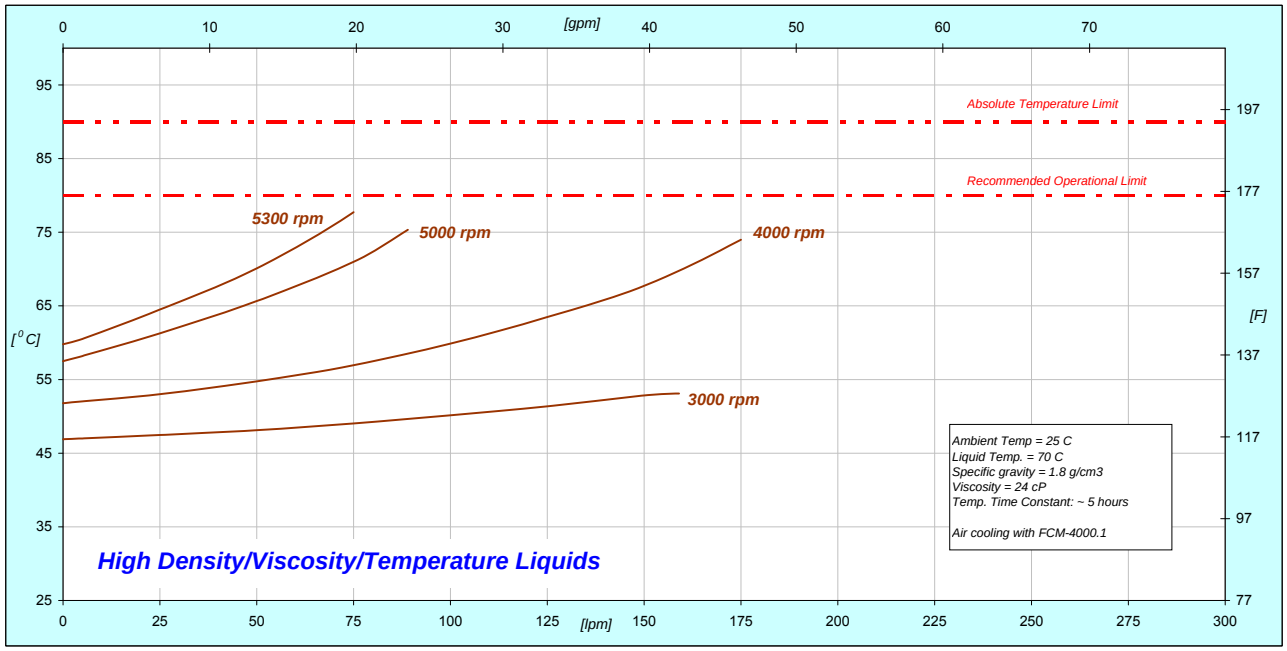
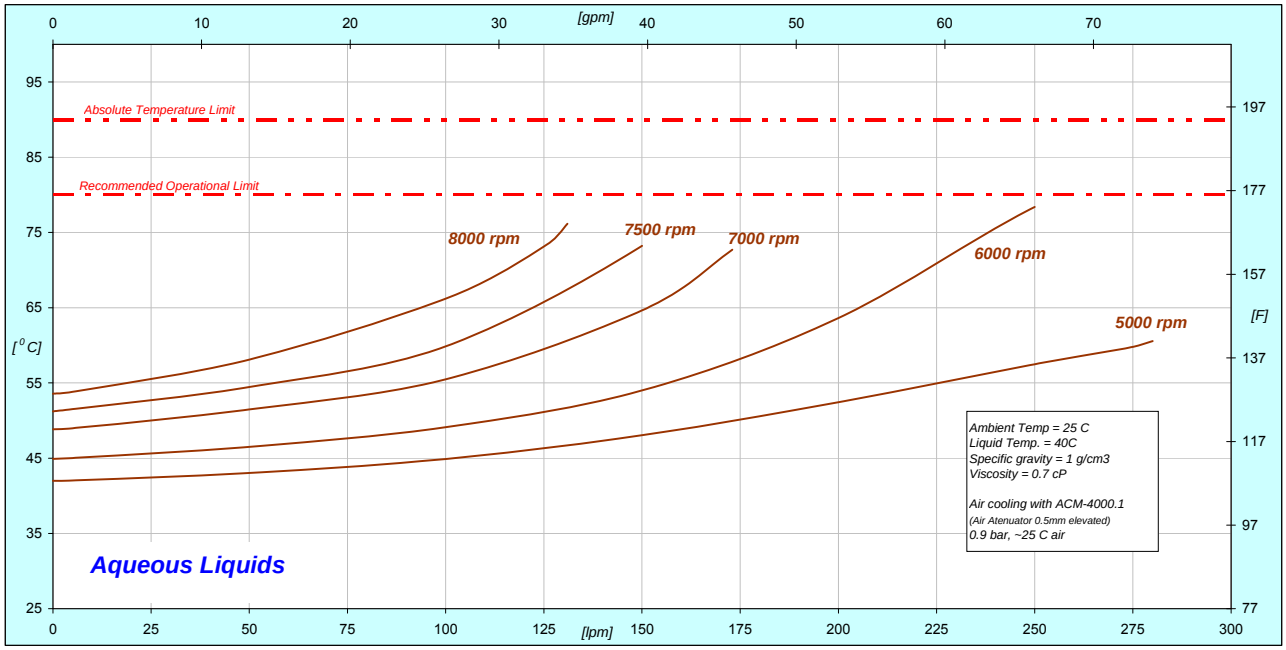


Figure 20: Temperature curves of motor LPM-4000.2 with fan cooling module FCM-4000.1
(Pump head LPP-4000.1, Fan Cooling Module FCM-4000.1 at 25°C)



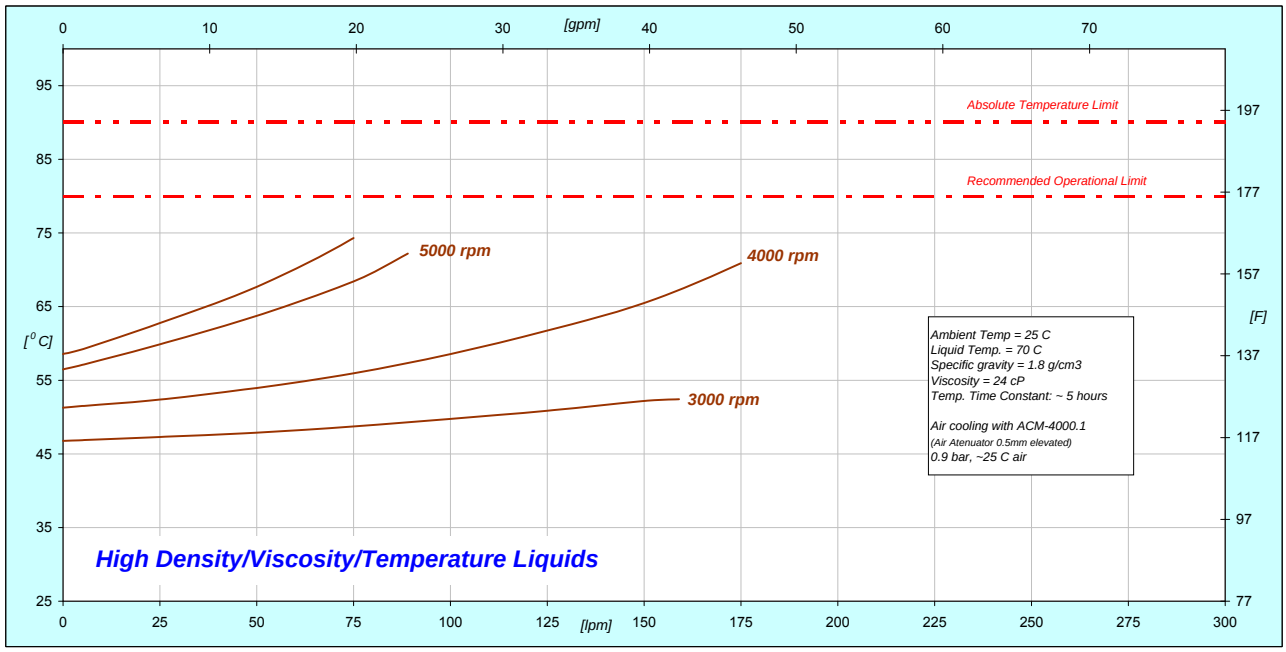


Figure 21: Temperature curves of motor LPM-4000.2 with air cooling module ACM-4000.1 & 3

(Pump head LPP-4000.1, Air Cooling Module ACM-4000.1 with 0.9 bar air at 25°C)

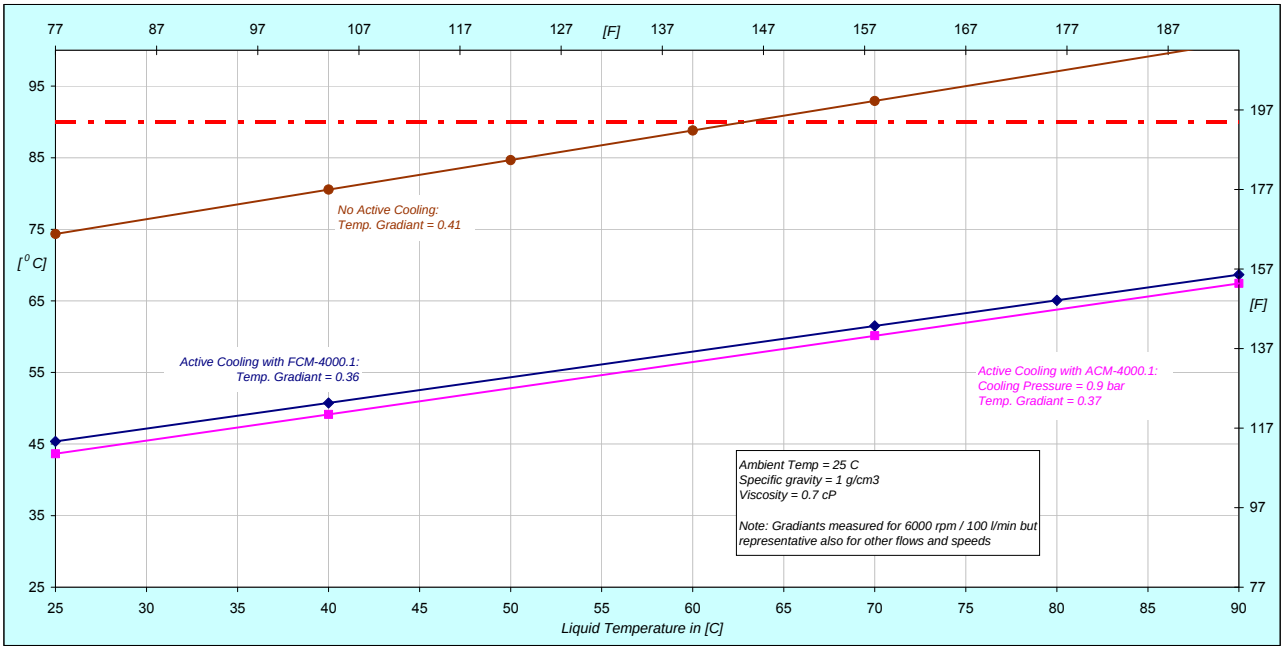


Figure 22: Influence of liquid temperature on motor temperature
(Measurement at 6000 rpm 100 lpm, but gradients are representative for other operational points)

The above curves are measurements of the motor temperature at certain liquid and ambient temperatures. Equation *(Eq. 1)* shows how to calculate the motor temperature for other liquid and ambient temperatures based on these curves.

$$T_M(T_L,T_A) \approx \underbrace{T_M(T_L = 25^0C, T_A = 25^0C)}_{\text{see Figure 19}} + (T_L - 25^0C)\cdot \underbrace{tg_{LM}}_{\text{see Figure 22}} + (T_A - 25^0C)$$

(Eq. 1)

T_M	=	*Motor temperature*	T_L	=	*Liquid temperature*
T_A	=	*Ambient temperature*	tg_{LM}	=	*Temperature gradient liquid/motor*

In order to account for thermal variations (like ambient temperature, closed chemical cabinets or corners without ventilations) and to not significantly reduce the MTBF of the motor it is recommended to keep about 10 to 20°*C* safety distance to the absolute thermal limit of the motor (90°*C*) when designing the thermal concept of the pump system.

3.4.2 Controller Temperature

Depending on the ambient temperature and the placement of the controller additional cooling may be required (see *Figure 23*). To improve cooling of the controller, place the device into a moving air stream. If the controller is mounted in a compact area or adjacent to additional heat sources (e.g. a 2nd controller) ensure that there is sufficient ventilation.

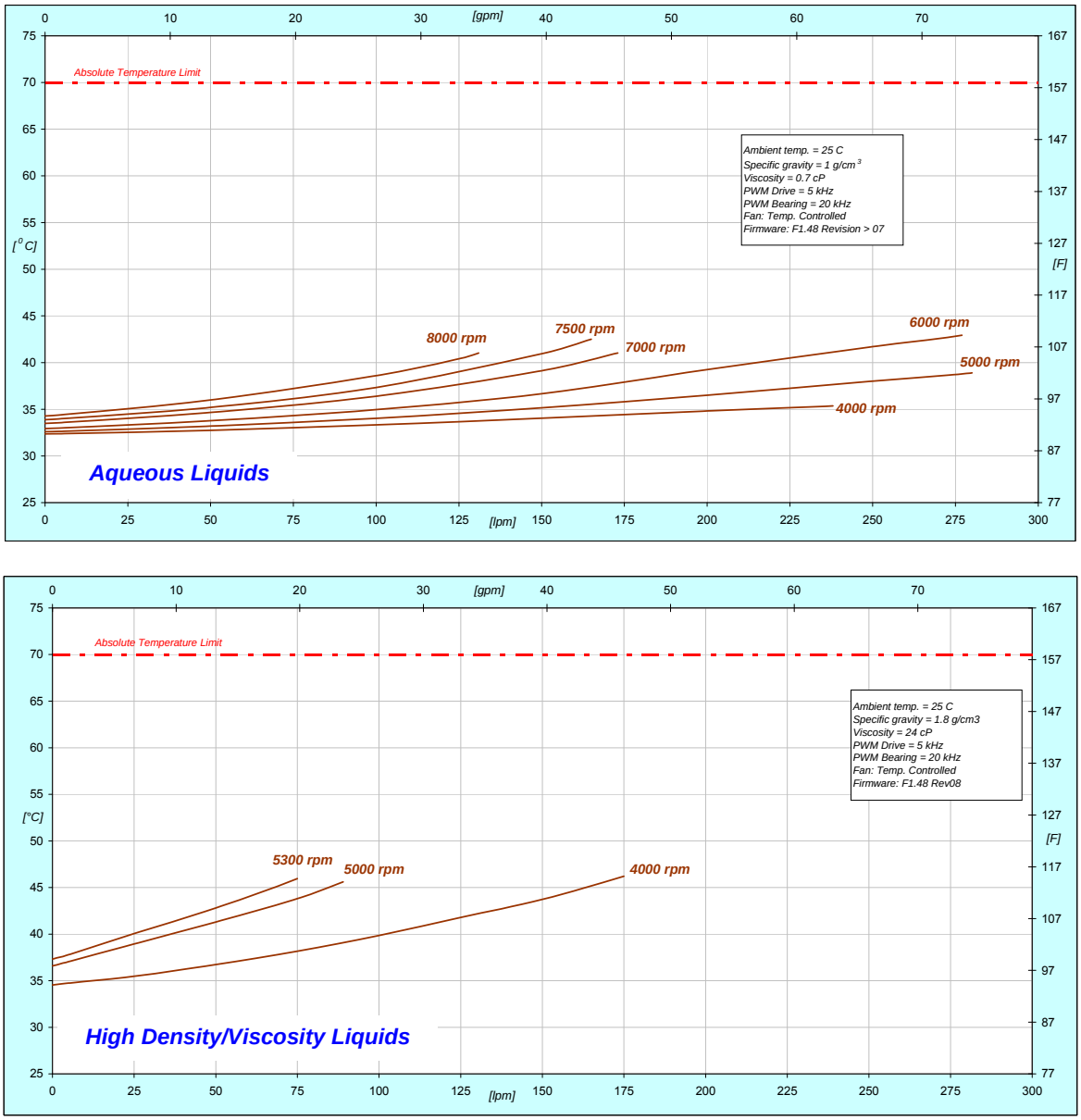


Figure 23: Temperature curves of controller LPC-4000 vs. flow and speed
(for pumping with pump head LPP-4000.1 and motor LPM-4000.2)

The above curves are measurements of the controller temperature at 25°C ambient. Equation *(Eq. 2)* shows how to calculate the controller temperature for at other ambient temperatures based on this curve.

$$T_C(T_A) \approx \underbrace{T_C(T_A = 25^0 C)}_{see\ Figure\ 23} + (T_A - 25^0 C)$$

T_C = *Controller temperature*
T_A = *Ambient temperature*

(Eq. 2)

4 Installation

4.1 Electrical Installation of Controller

4.1.1 Overview

The *LPC-4000* controllers have signal processor controlled power converters with six switched inverters for the drive and the bearing windings of the motor. The signal processor allows precise control of pump speed and impeller position. *Figure* 24 shows the interfaces of the standalone controller *LPC-4000.1* with stand-alone and minimal PLC functions and *Figure* 25 the interfaces of the controller *LPC-4000.2* with extended PLC functions and USB interface for communication.

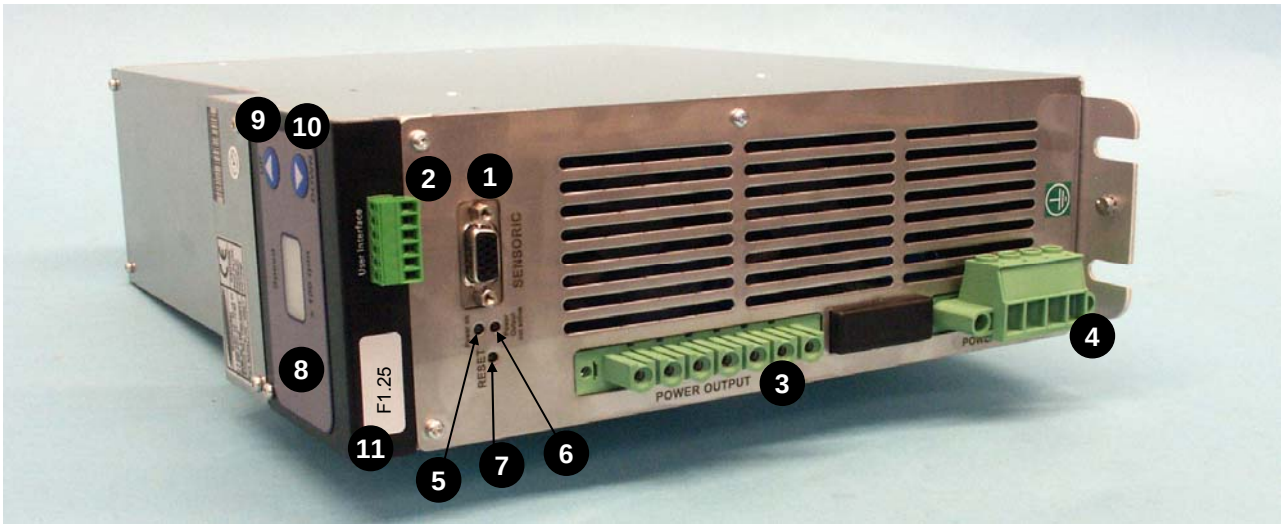


Figure 24: Overview of the controller LPC-4000.1 for standalone operation

	Interface (as labeled)	Description	
1	"SENSORIC"	Position, field and temperature sensor signals from motor	
2	"USER INTERFACE"	1 Digital Input	- Galvanic isolation with optocoupler - Switching voltage / current: minimal 5 V / 7 mA, Typical 24 V / 16 mA, maximal 30 V / 20 mA - Input resistance: R_{IN} = 2.2 kΩ
		1 Digital Output	- Galvanic isolation with relay - Relay: 1A / 30VDC, 0.3A / 125 VAC
		1 Analog Input	- Analog current input: 4 – 20 mA - 450 Ohm shunt input
3	"POWER OUTPUT"	Drive and bearing currents of the motor	
4	"POWER INPUT"	DC power input	
5	"Power on" Green LED	LED is on if supply voltage of signal electronics is present.	
6	"Power Output not active" Red LED	Red LED is off if the switched output stage of the controller is enabled. If the LED is on, the bearing and drive coils of the motor carry no current.	
7	"RESET" Button	Reset button of the controller stage. The button is sunk mounted and can be activated for example with a small screw driver.	
8	2-Digit Display "Speed"	Rotational speed display in 100rpm	
9	"UP" Button	Button for speed increasing	
10	"DOWN" Button	Button for speed decreasing	
11	"Firmware" Label	Firmware version and revision number	

Table 7: Description of interfaces of LPC-4000.1 controller

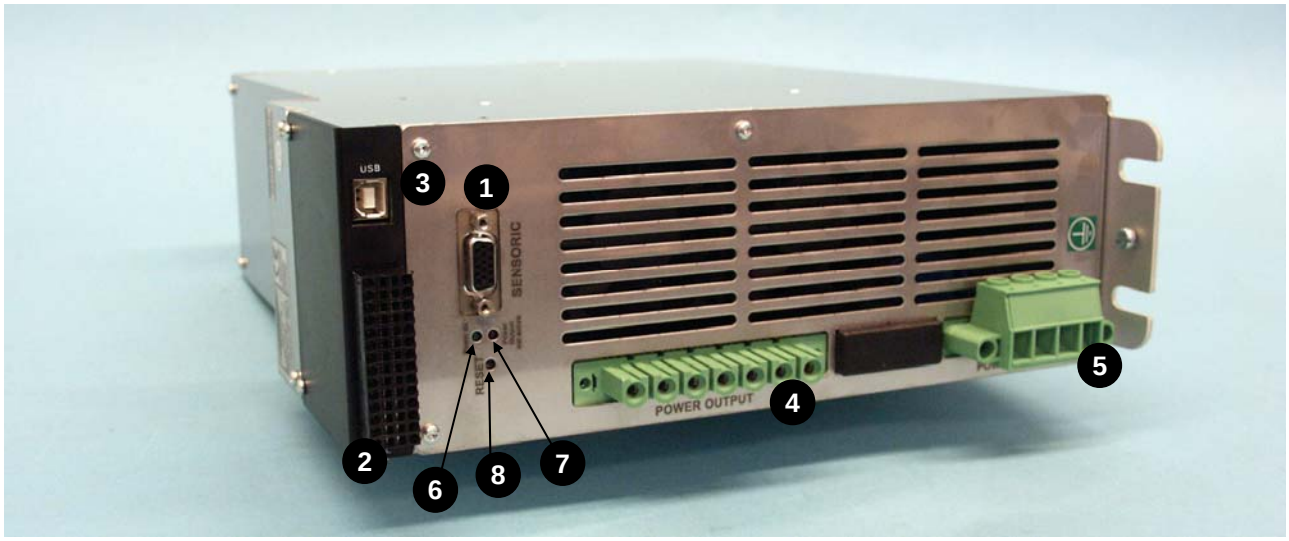


Figure 25: Overview of the controller LPC-4000.2 for extended operation

	Interface (as labeled)	Description	
1	"SENSORIC"	Position, field and temperature sensor signals from motor.	
2	"USER INTERFACE"	2 Analog Input	- Analog current input: 4 – 20 mA - 450 Ohm shunt input
		2 Analog Input	- Analog voltage input 0 – 10 V - Direct connection, no galvanic isolation - 7.8 kΩ input resistance
		2 Analog Output	- Analog voltage output: 0 – 10 V - - Direct connection, no galvanic isolation - - Max. Output current: 2mA
		4 Digital Input	- Galvanic isolation with optocoupler - Switching voltage / current: minimal 5 V / 7 mA, - Typical 24 V / 16 mA, maximal 30 V / 20 mA - Input resistance: R_{IN} = 2.2 kΩ
		4 Digital Output	- Galvanic isolation with relay - Relay: 1A / 30VDC, 0.3A / 125 VAC
3	"USB"	USB interface	
4	"POWER OUTPUT"	Drive and bearing currents of the motor.	
5	"POWER INPUT"	DC power input	
6	"Power on" Green LED	LED is on if supply voltage of signal electronics is present.	
7	"Power Output not active" Red LED	LED is off if the switched output stage of the controller is enabled. If the LED is on, the bearing and drive coils of the motor carry no current.	
8	"RESET" Button	Reset button of the controller stage	

Table 8: Description of interfaces of LPC-4000.2 controller

4.1.2 General Installation Instructions

WARNING

Hazardous voltage may be present.

Always isolate the electrical power supply before making or changing connections to the unit. To remove the power it is recommended to use an over-current or circuit breaker in close proximity to the controller.

WARNING

Hazardous voltage may be present.

The controller housing must be properly grounded. Use the specified screws on the feet of the controller housing.

WARNING

Incorrect assembling of the "POWER INPUT" connector
➔ short circuit possible.

Assure that the pin assignments of the "POWER INPUT" connector are correct before it is plugged in.

1. Connect the protective earth wire with a crimp-type end on the specified earth screw (see *Figure 26)* on the feet of the controller (see also protective earth labels on controller).
2. Connect the two motor connectors (sensor and power) to the controller. Assure that the "POWER OUTPUT" connector from the motor is correctly aligned with the connector of the controller before it is plugged in.
3. Connect the AC power input connector. Make sure that the pin connections are correct (see *Figure 26)*:
   - *1 x 200-240V (1-phase) ⇒ L1 (⇒ L), L2 (⇒ N), PE (= Protective Earth)*
   - *3 x 200-240V (3-phase) ⇒ L1 ,L2, L3, PE (lines can be switched), Y-voltage = 115 – 139V AC*
   - *Minimum Wire Gauge = AWG 12 (cooper diameter = 2.052 mm, crosssection = 3.3 mm^2)*
   - *External fuses of 25A / medium (m) in all power lines are recommended*
4. To secure the connectors, tighten all retaining screws.

Figure 26: AC power input and protective earth of LPC-4000 controller

4.1.3 Electrical Installation of Controller LPC-4000.1 for Standalone Operation

For standalone operation the *LPC-4000.1* is disabled when power is turned on. It can be enabled manually by using the "UP" button on the display. If the controller shall be enabled automatically, when power is applied the "ENABLE" pin on the "USER INTERFACE" connector (see *Table 9*) has to be active (typically 24V).

4.1.4 Electrical Installation of Controller LPC-4000.1 for Extended Operation

If the *LPC-4000.1* shall to be controlled with external signals the "USER INTERFACE" can be used with the PIN designations described in *Table* 9.

Pin Name	*Connector Pin Number*	*Designation*	*Levels*	*Note*
Analog In, (Signal)	5	Reference Speed	4..20 mA = 0..10000 rpm → Speed Limit = 8000 rpm ≙ 16.8 mA → Cut-off (min.) speed = 300 rpm	Direct connection, no protection. Galvanic isolation on the user side is required.
Ground Analog In	6			
Digital In, (Signal)	3	Enable	24 *V* ⇒ active 0 *V* ⇒ not active	Is needed to enable the system with an external signal.
Ground Digital In	4			
Digital Out	1	Status	Relay closed ⇒ active, system on Relay open ⇒ not active, system off	This signal indicates if the system is active.
Ground Digital Out	2			

Table 9: Description of „USER INTERFACE" connector
(Description is for firmware F1.25, for other configurations refer to alternate firmware documentation)

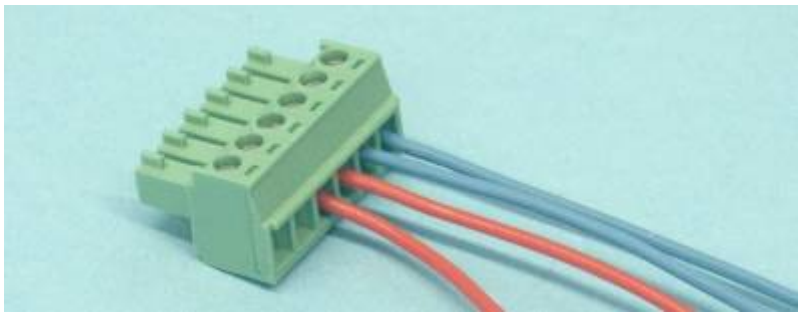


Figure 27: „USER INTERFACE" connector
- Delivered with controller LPC-4000.1
- Supplier: PTR Messtechnik GmbH, Germany
- Connector Type: AK1550/06-3.81-GREEN

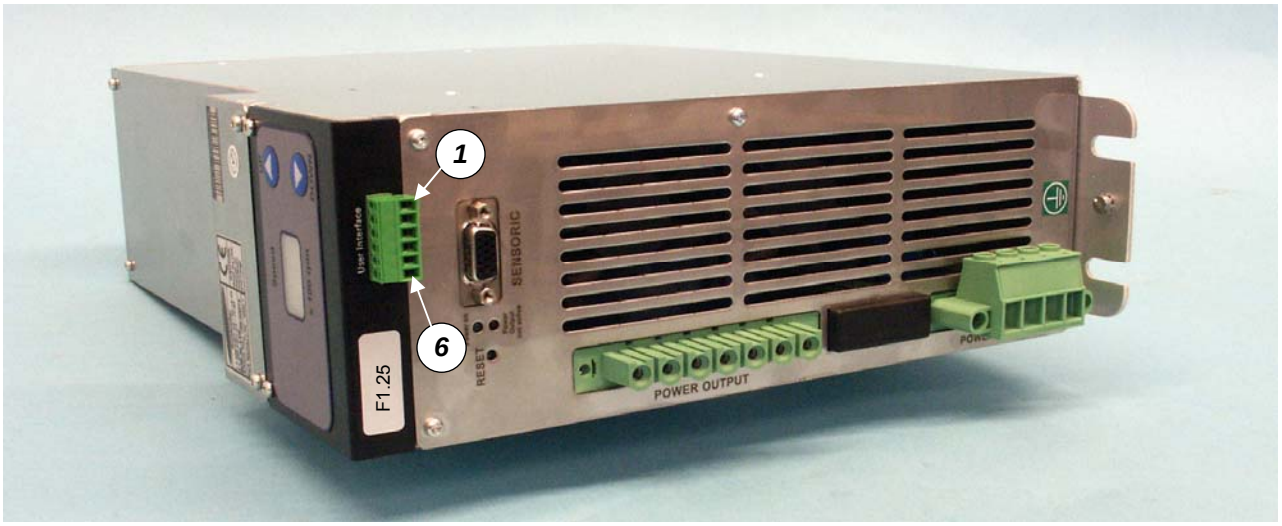


Figure 28: Mounted "USER INTERFACE" connector and Pin numbering

4.1.5 Installation of PLC Interface for Extended Controller LPC-4000.2

To operate the pump system with a PLC, a minimum set of two digital inputs and one analog input is needed. The digital and analog outputs can be used to monitor the pump status and operating parameters.

CAUTION

The analog inputs and outputs are not galvanic isolated from the controller electronics. To avoid ground loops and mal-functions, use floating analog signals.

1. Detach the PLC connector from the controller
2. Connect the designated wires of a cable the pins of the detached connector according to *Table 10.* Assignment and functions of the I/Os can be changed with the controller firmware version (refer to according firmware documentation).
3. Connect the PLC connector (*Figure 29*) to the controller.

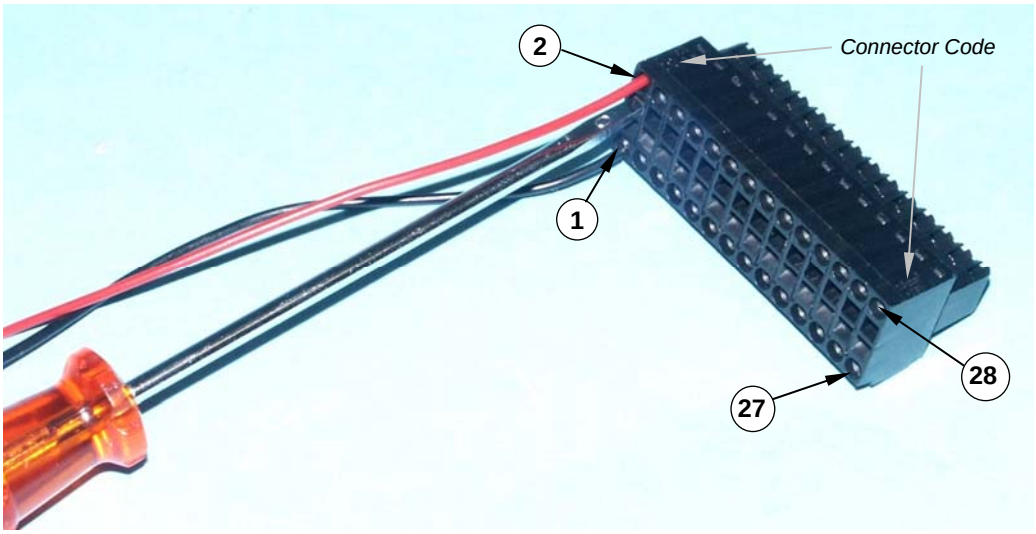


Figure 29: PLC connector

- Delivered with controller LPC-4000.2
- Supplier: Weidmüller
- Connector Type: B2L 3.5/28 SN BK BX

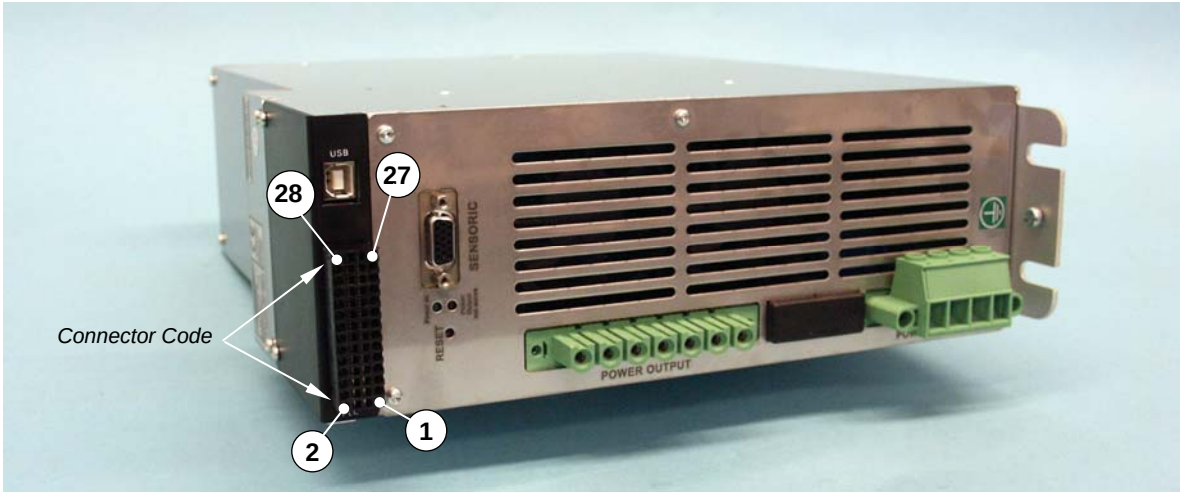


Figure 30: Mounted PLC connector and Pin numbering

Wire name	***Connector Pin***	***Designation***	***Levels***	***Note***
Analog In1, (Signal)	18	*Ref Value (Current Input)*	4..20 mA = 0..10000 rpm *(speed mode)* → Speed Limit = 8000 rpm ≙ 16.8Ma → Cut-off (min.) speed = 300 rpm 4..20 mA = 0..100% *(process mode)*	- Grounds are internally connected - Direct connection, no protection. Galvanic isolation on the user side is required. - Default input settings: Current inputs selected. Voltage input can be selected with EEPROM–editor in Service Software (consult detailed firmware specification *F1.48* and Service Software Manual with Doc.# *PL-2034-00*)
Ground Analog In1	17			
Analog In2, (Signal)	20	*Actual Process Control Value (Current Input)*	4..20 mA = 0..100%	
Ground Analog In2	19			
Analog In3, (Signal)	22	*Ref Value (Voltage Input)*	0..10 V = 0..10000 rpm → Speed Limit = 9000 rpm ≙ 9 V → Cut-off (min.) speed = 300 rpm 0..10 V mA = 0..100% *(process mode)*	
Ground Analog In3	21			
Analog In4, (Signal)	24	*Actual Process Control Value (Voltage Input)*	0..10 V = 0..100 %	
Ground Analog In4	23			
Analog Out1, (Signal)	26	*Actual Speed*	0..5 V = 0..10000 rpm	Direct connection, no protection. Galvanic isolation on the user side is required.
Analog Out2, (Signal)	28	*Actual Process Control Value*	0..5 V = 0..100%	
Com. Ground Analog Out	25, 27	--	--	
Digital In1, (Signal)	2	*Reset*	24 *V* ⇒ active 0 *V* ⇒ not active	Resets error state
Ground Digital In1	1			
Digital In2, (Signal)	4	*Process mode*	24 *V* ⇒ active 0 *V* ⇒ not active	Switches between process mode and speed mode
Ground Digital In2	3			
Digital In3, (Signal)	6	*Enable*	24 V ⇒ active, system on 0 V ⇒ not active, system off	The Enable signal switches the pump system on and off.
Ground Digital In3	5			
Digital In4, (Signal)	8	*Not used*	--	--
Ground Digital In4	7			
Digital Out1	10	*Status*	Relay closed ⇒ active, system on Relay open ⇒ not active, system off	This signal indicates the state of the pump system.
Ground Digital Out1	9			
Digital Out2	12	*Error*	Relay closed ⇒ not active, system on Relay open ⇒ active, system off	When active, the system drives the impeller to zero rpm and shuts down. With a reset pulse the system can be re-initialized.
Ground Digital Out2	11			
Digital Out3	14	*Warning*	Relay closed ⇒ not active, system o.k. Relay open ⇒ active, system not o.k.	The warning signal indicates if a system fault has been detected. The warning signal indicates a system fault but the system does not shut down
Ground Digital Out3	13			
Digital Out4	16	*Trend Warning*	Relay closed ⇒ warning active Relay open ⇒ warning not active	Default setting: Relay closed if trend warning is active. Can be changed in EEPROM with Service Software
Ground Digital Out4	15			

Table 10: Signals of the PLC connector for standard firmware F1.48
(For other configurations of PLC inputs and outputs refer to alternate firmware documentation.)

4.2 Mechanical Installation of the Pump/Motor

4.2.1 Standard Installation Instructions and Information

⚠ WARNING

Overheating of the Motor Power and Extension Power Cable

To prevent an overheating of the motor power and extension power cables, do not roll-up or install several motor power cables in the same cable channel. This is has especially to be considered when long motor power cables are used.

- The motor can be fixed with four screws on the motor feet (see *Figure 9*)
- As an alternative the motor can be mounted with 12 screws on the back (see *Figure 9*)
- The motor can be mounted in either the horizontal or vertical position
- Each motor is identified with a unique serial number. This serial number consists of a series of 6 digits were the 5th and the 6th digit representing the manufacturing year.
- To prevent an overheating of > 90°C of the motor power cable in extension power cable, please don't roll-up or install several motor power cables in the same cable channel.

4.2.2 Installation of ATEX Motors

⚠ WARNING

Motors for ATEX applications. Only specific types of motors LPM-4000 are classified for the use in ATEX Zone 2 classified locations. Refer to the corresponding section in the manual.

⚠ WARNING

*Motors for ATEX applications. Use only, if necessary, the cooling module **ACM-4000.3** for motors installed in ATEX Zone 2 classified locations. The use of the Fan Cooling Module FCM-4000.1 is not allowed in ATEX applications.*

An ATEX conform solution is needed for the motor cable to leave the ATEX area (see *Figure 5*). One option is an ATEX certified cable sealing system as listed in *Table 4* (see *Pos. 8*) and shown in *Figure 2*.

A protective earth wire shall be attached to the ATEX specific motor housing by using one of the eight M8 threads on the backside of the motor.

- Remove one of the eight M8 screws on the backside of the motor
- Use a crimp-type end together with a spacer sleeve to connect a earth wire
- Attach the grounding wire with a M8 stainless steel screw to the motor according to

Figure 31: Attachment of a protective earth wire to the backside of the motor

4.3 Mechanical Installation of the Controller

- The controller can be fixed with four screws (for example M7) on the Controller feet (see *Figure 13*)
- If no forced air-cooling is used, mount the controller in upright position and assure that the heat of the controller can dissipate. Avoid mounting the controller in a cabinet were heat is stagnated and accumulated.

WARNING

Hazardous voltage may be present.

In order to avoiding fluid spills shorting mains or other voltages within the controller, place the controller in a spill protected environment (for example protected electronic cabinets).

If explosive flammable gases are present, place the controller in an explosion-proof cabinet.

CAUTION

Do not under any circumstances open the controller. Levitronix does not assume responsibility for any damage, which occurs under such circumstances.

5 Operation

5.1 System Operation with LPC-4000.1 (Stand-Alone Version)

5.1.1 State Diagram of LPC-4000.1

The controller *LPC-4000.1* allows stand-alone operation with manual speed setting ("Button Control Mode") as well as extended operation with analog speed setting (Analog Control Mode). *Figure 32* shows the state diagram which can be controlled with the manual buttons and the signals on the "USER INTERFACE" connector. The operation mode can be chosen by pressing the "UP" and "DOWN" buttons simultaneously during 5 seconds. For the standard firmware *F1.25* default setting ex factory is "Button Control Mode".

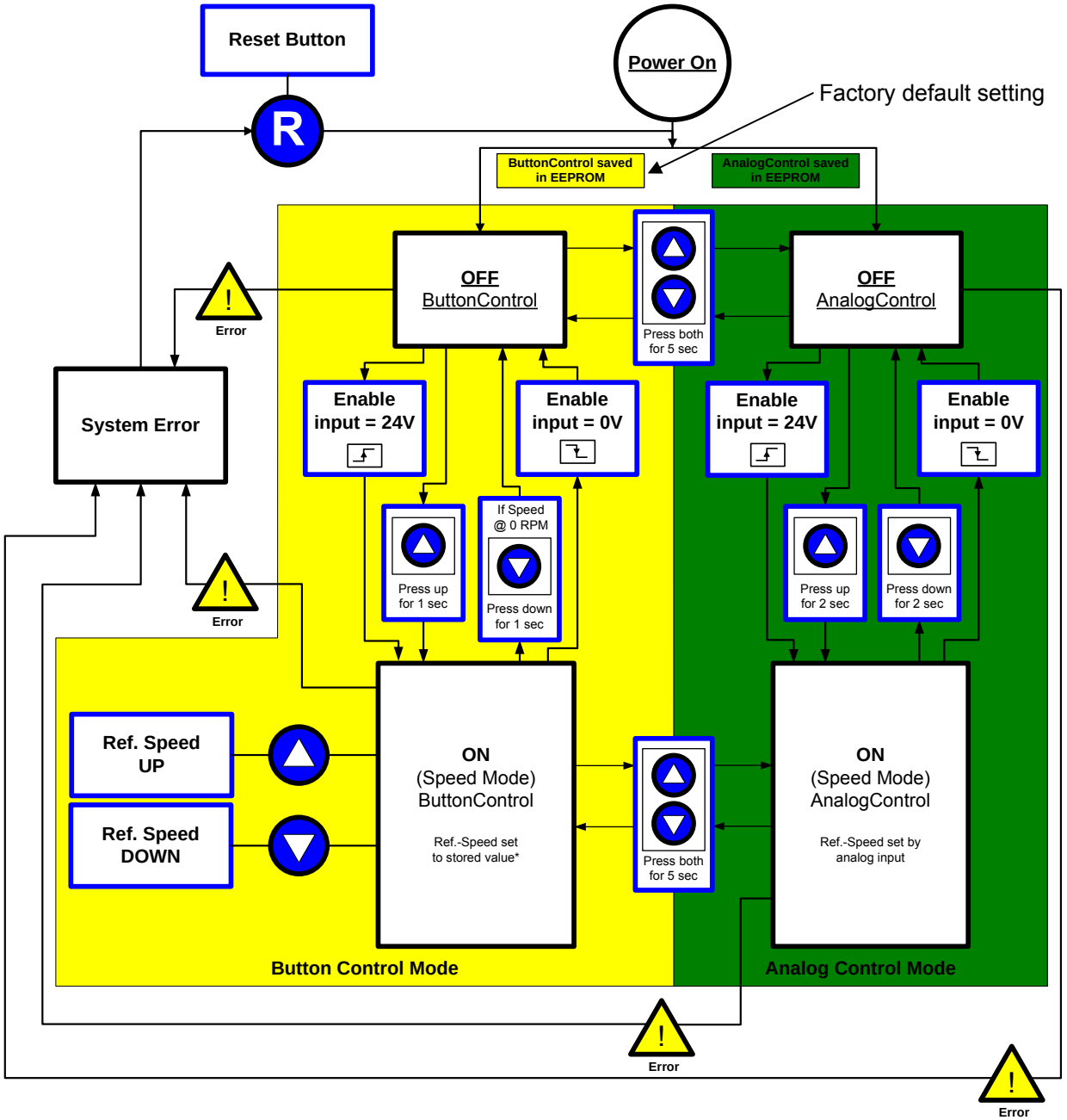


Figure 32: State diagram for operation with LPC-4000.1 controller
(Description is for firmware F1.25, for other configurations refer to alternate firmware documentation)

5.1.2 Standalone Operation (Button Control Mode)

- When applying power the system defaults into the “Button Control Mode” and goes into the status “OFF ButtonControl” according to *Figure 32*. Levitation is disabled and the display indicates “OF”.
- Levitation can be enable by pressing the “UP” button during 1 second (display shortly indicates “ON”) or by activating (typically 24V) the “ENABLE” pin on the “USER INTERFACE” connector (see *Table* 9). The system goes then into the status “ON Button Control” and is running at the speed which is stored in the EEPROM.
- The speed can be changed by pressing accordingly the “UP” and “DOWN” buttons. As long as the digits on the display are blinking the set speed is shown. As soon as blinking stops the actual speed is shown and the set-speed is stored in the EEPROM of the controller after about 2 seconds.
- The system can be disabled by pressing the “DOWN” button until 0 rpm is achieved. Pressing further 1 second the “DOWN” button the system disables levitation and shows “OF” on the display. The system can also be disabled by deactivating (0 V) the “ENABLE” pin on the “USER INTERFACE” connector (see *Table* 9). Before disabling the system the speed is automatically reduced to 0 rpm and the impeller is properly touched down without grinding the wall.
- In case of an error the “RESET” button (see *Table* 7) can be used to restart the system or the power can be switch off and on. For detailed error analysis the codes described in *Table* 11 are shown on the two digit display (blinking between “Er” and the according code number).

Figure 33: User Panel of LPC-4000.1

5.1.3 Extended Operation ("Analog Control Mode")

- In order to be able to control the pump with external signals (PLC) the mode "Analog Control Mode" has to be set with the display buttons. The "UP" and "Down" buttons have to be pressed simultaneously during 5 seconds. The display should feedback the change by blinking between the stored speed value and "An". The chosen mode is then stored in the EEPROM of the controller.
- The system and levitation can be enabled/disabled with the digital input on the "USER INTERFACE" connector (see *Table* 9). When disabling the running system, the speed is automatically reduced to 0 rpm and the impeller is smoothly touched down without grinding the wall.
- The speed can be set with an analog signal on the "USER INTERFACE" connector according to *Table* 9. It is strongly recommended to use galvanic separated signal values
- For monitoring purposes a digital output on the "USER INTERFACE" connector (see *Table 9*) indicates an error. In case of an error the codes described in *Table 11* are displayed (blinking between "An" and the according code number)

5.1.4 Error Display on the Integrated Panel

Error Source	Errors	Error Code on Display
Motor	No Motor	*Er 01*
Motor	Motor cable (power wires) not connected to controller	*Er 02*
Motor	Motor cable (sensor wires) not connected to controller	*Er 03*
Motor	No Rotor	*Er 04*
Controller	Short circuit	*Er 05*
Controller	Over current in the bearing coils	*Er 06*
Controller	Over current in the drive coils	*Er 07*
Controller	DC-Link voltage out of range → Voltage range for monitoring: 243 – 378 V DC → If the voltage is out of range the system starts to reduce the speed. When reaching 0 rpm and the voltage is still out of range an Error is generated. → In case the voltage is again within the range during speed reduction the system switches to normal operation and no Error is generated.	*Er 08*
Controller	Communication problems EEPROM Controller	*Er 09*
Motor	Communication problems EEPROM Motor	*Er 10*
Controller	Controller temp. over 80°C or more than 10 minutes above 70°C	*Er 11*
Motor	Motor temp. over 100°Cor more than 10 minutes above 90°C	*Er 12*
Pump	Dry running of pump circuit: → Pump keeps running on reduced speed (5000 rpm) → The system accelerates to the original speed value when the pump is refilled with liquid → Note that the speed is only reduced during dry running if the pump speed was ≥ 6000 rpm.	*Blinking dots on display*

Table 11: Errors and warnings with indication on display of LPC-4000.1
- In case of an error the system can only be restarted with a reset or a power supply restart
- Standard firmware is F1.25
- For other configurations of error codes refer to alternate controller or firmware documentation

5.2 System Operation with Controller LPC-4000.2 (PLC version)

5.2.1 State Diagram of the PLC Interface

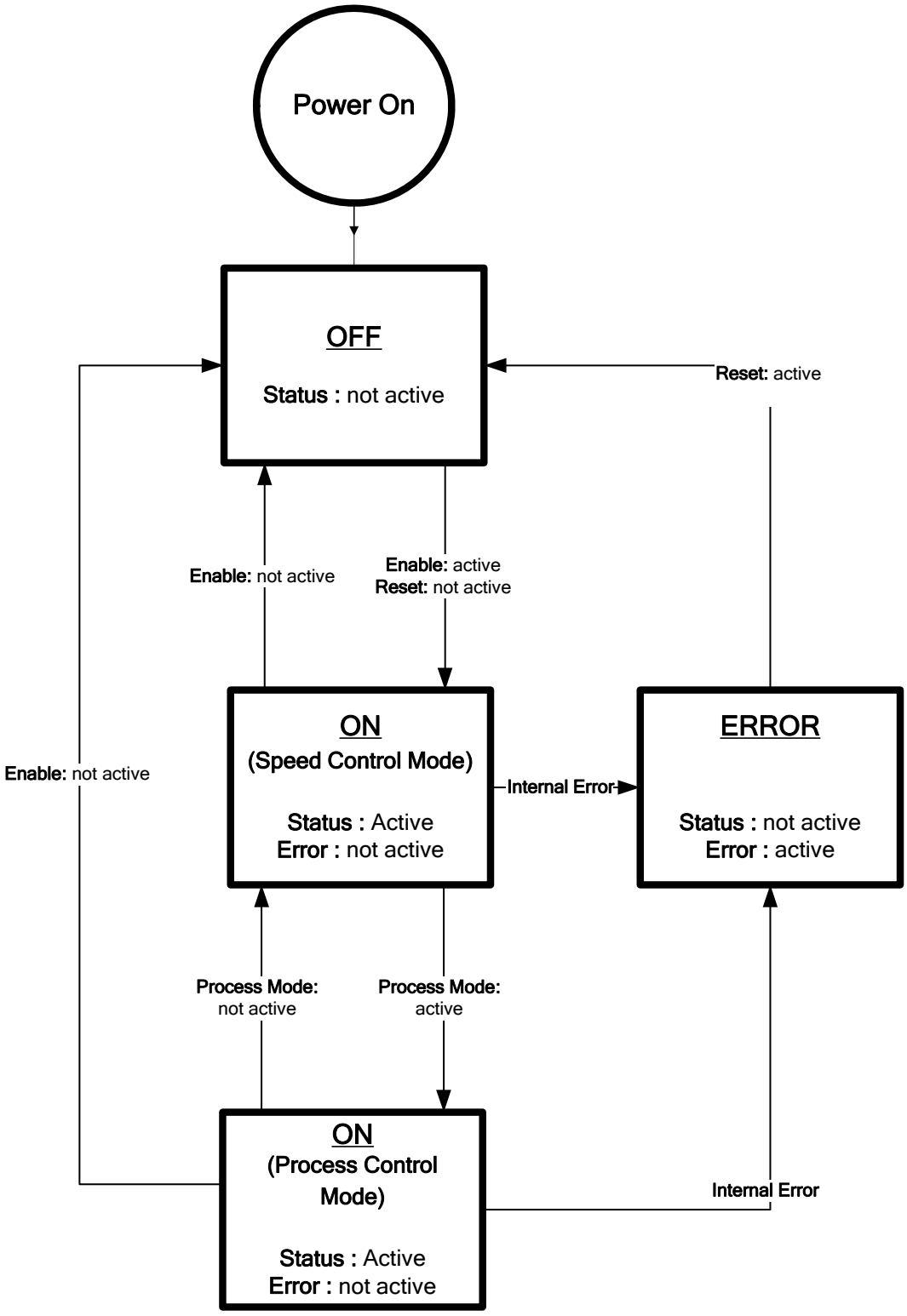


Figure 34: PLC interface state diagram for standard firmware F1.48
(For other configurations refer to alternate firmware documentation)

State "Off":
The pump system is switched off and the motor has no power. In this state, Levitronix Service Software has full control.

State "ON" (speed control mode):
The pump system is switched ON and the impeller is rotating with the referenced speed. The motor has electrical power when in this state.

State "ON" (process control mode):
The pump system is switched ON and the impeller speed is controlled in order to get the referenced flow/pressure. The motor has electrical power when in this state.

State "Error":
If an error according to *Table* 12 occurs in the pump system, the system defaults to the *Error* state. The designated digital output on the PLC Interface is activated. The pump system is switched OFF. By activating the "*Reset*" input the system gets back to the "*Off*" state.

Error Source	***Errors***	***Effect on Designated Digital Output of the PLC***
Motor	No rotor	*Error = relay open*
Motor	Temperature over 100°C	*Error = relay open*
Motor	Temp. was higher than 90°C for more than 10 minutes.	*Error = relay open*
Motor	Temperature more than 90°C	*Warning = relay open*
Motor	No motor temperature signal	*Warning = relay open*
Motor	Motor power cable not connected with controller	*Error = relay open*
Motor	Motor sensor cable not connected with controller	*Error = relay open*
Controller	Over-current	*Error = relay open*
Controller	Power channel interrupted	*Error = relay open*
Controller	Temperature over 80°C	*Error = relay open*
Controller	Temp. was higher than 70°C for more than 10 minutes.	*Error = relay open*
Controller	DC link (supply voltage) out of range (< 243 or > 378 V DC) If the voltage is out of range the system starts to reduce the speed and a warning is generated. When reaching 0 rpm and the voltage is still out of range the system is disabled and an error is generated. In case the voltage is again within the range during speed reduction the system switches to normal operation and no Error is generated.	*Error = relay open*
Controller	Temperature over 70°C	*Warning = relay open*
Controller	Dry Running Detection → Pump keeps running on reduced speed (5000 rpm) → The system accelerates to the set speed value when the pump is refilled with liquid → Note that the speed is only reduced during dry running if the pump speed was ≥ 6000 rpm	*Warning = relay open*

Table 12: Errors and warnings with indication on PLC interface for standard firmware F1.48
(For other configurations refer to alternate firmware documentation)

5.3 System Operation for ATEX Applications

5.3.1 General Safety Requirements

Specific precautions may be considered while using the pump system in potential explosive gas atmospheres according to ATEX category 3G/3D (Zone 2 and 22).

The user shall prevent priming issues during normal pump operation. Especially precautions have to be considered during installing and maintenance operations to prevent the occurrence of combustible atmospheres.

The user shall prevent electrostatic charging of the system at cleaning processes by using dry cleaning cloth. User shall use wet cleaning rags to avoid issues with charging during a cleaning process.

CAUTION

Precautions have to be considered to prevent priming issues during installation operation and maintenance of the pump head / motor.

WARNING

Operational Temperature T5
Maximum allowed pump liquid temperature is 90°C / 194°F for the use in ATEX Zone2 applications.

WARNING

Do not operate the pump against closed valves
Refer to the corresponding section in the manual.

5.3.2 Control of Motor Casing Temperature

To avoid high motor casing temperatures and to control the temperature sensor operation the following steps shall be considered:

For operation with the *LPC-4000.2* controller the "*Digital Out 3*" of the PLC connector (see *Table 10*) shall be monitored for warnings during operation in order to check if the communication to the temperature sensor is established. If "*Digital Out 3*" is active (this output indicates warnings caused by various sources, inter alia communication problems with the motor) the pump system may be checked for correct operation. The motor temperature readings can be monitored via the *Levitronix Service Software*.

For standalone operation with the *LPC-2000.1* controller the display shall be checked periodically for error messages according to *Table 11 (*see error *Er10 = "Communication problems EEPROM Motor*").

Additionally the motor casing temperature shall be periodically measured and compared to the internal motor temperature readings. This comparison measurement checks potential drifts of the internal motor temperature sensor. Adhesive foil made of aluminum can be used to improve the thermal junction between motor casing and the external temperature sensor.

CAUTION

To prevent possible drifts of the motor temperature sensor the sensor shall be checked and compared to an external measurement of the motor casing temperature. This comparison measurement should be carried out at maintenance procedures every 12 month. The internal temperature sensor should not vary more than -10 °C to the external measurements. Positive drifts are not considered as critical.

6 Inspection and Maintenance

6.1 Replacement Interval of the Impeller

The impeller has a limited lifetime depending on the chemical type, concentration and temperature of the fluid which is pumped. Therefore a preventive periodical exchange of the impeller is recommended. Contact the *Levitronix Technical Service Department* (see *Section 8*) for further information on replacement times.

6.2 Impeller Replacement Procedure

6.2.1 Preparation

Before starting the impeller replacement procedure the parts and tools illustrated in *Figure 36* should be prepared. Impeller exchange kits, which contain these parts are available at Levitronix. *Figure 36* lists the standard components. For special configurations contact Levitronix. Please verify that you have the right types of impellers, O-rings and screws.

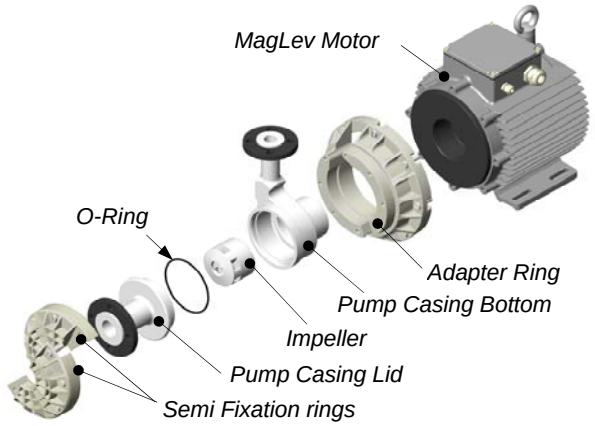


Figure 35: Explosion view of pump head with motor

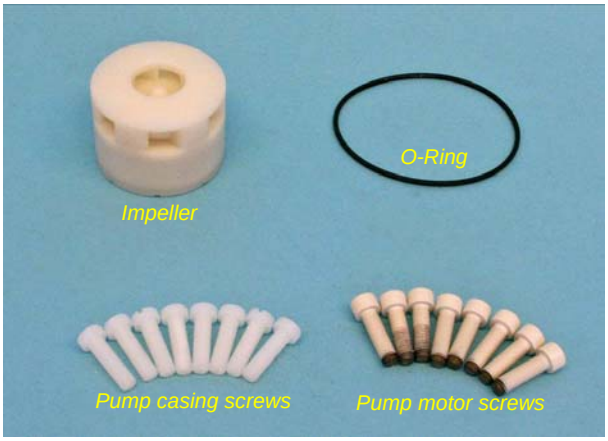


Figure 36: components for impeller replacement

The following warnings and cautions should be read carefully before starting the replacement of the impeller.

⚠ WARNING

The impeller could splash TOXIC or CORROSIVE CHEMICALS because of the strong magnetic forces. Flush the pump housing before opening it.

⚠ WARNING

HARMFULL CHEMICALS may be present.

Skin contact and toxic gases may be hazardous to your health. Wear safety gloves and other appropriate safety equipment.

⚠ CAUTION

The rotating impeller could cause injury. Do not run the pump system when opening the pump head.

CAUTION

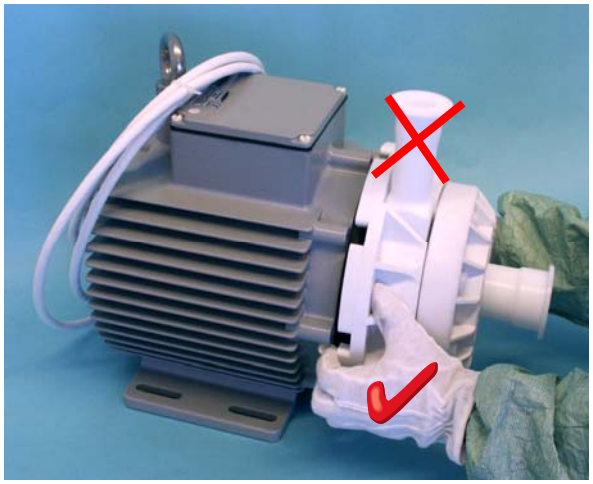
Pay attention to the magnetic forces when handling the impeller. The attraction of magnetic parts and particles should be avoided in order to keep the impeller and the pump head clean and free of contamination.

6.2.2 Instructions for Replacement

1. Power down the pump system and remove the AC supply voltage. It is necessary to let cool down to a workable temperature (near ambient) before the impeller can be exchanged.

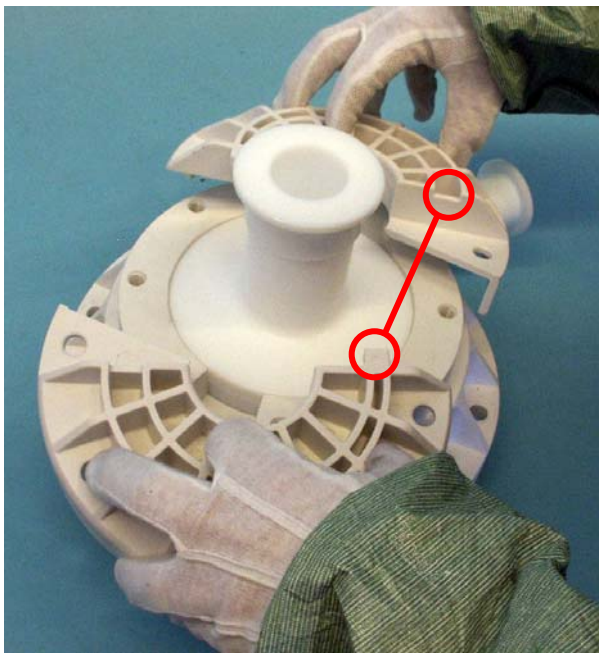
2. Unscrew the 8 PTFE coated stainless steel screws of the adapter ring after the motor is cooled down.

3. Remove the complete pump head from the motor. Make sure that the motor is fixed sufficiently to withstand the coupling forces of the impeller magnet. Do not use the inlet or outlet fitting to pull away the pump head as they are maid of PTFE with limited strength.



4. Unscrew the 8 screws on the both semi fixation rings.

5. Twist the semi fixation rings together to release the snap clips and separate it from the pump head. Alternative use 2 screwdriver to lift the snap clips.



6. Press the adapter ring down.

7. Remove the pump housing lid with the sealing ring. Remove the impeller. Inspect the wet area of the pump head carefully. In case of material damage, also replace the pump casing.

⚠ CAUTION

Pay attention to the magnetic forces when handling the impeller. The attraction of magnetic parts and particles should be avoided in order to keep the impeller and the pump head clean and free of contamination. Avoid magnetic and metal parts within a radius of about 1 meter.

8. Replace the impeller. If necessary, remove the existing *O-Ring* and press the new *O-Ring* into the lid of the pump casing.

CAUTION

Use always the specified O-Ring type. If necessary, consult the Levitronix Technical Service Department. Do NOT twist or roll the O-Ring as this may cause leaking to occur.

9. Press the lid with the O-ring flush into the bottom of the pump casing.

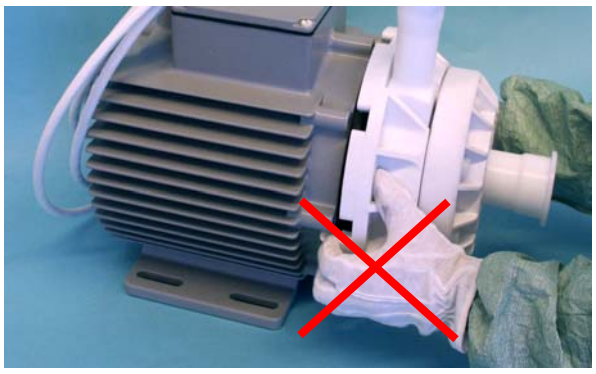
10. Press the pump casing into the adapter ring and add both fixation rings.

11. Tighten the 8 PVDF screws crosswise and symmetric regular on the semi fixation rings. The screws should not be used to press the lid with the O-ring into the bottom of the pump casing. Do not apply too much torque. The torque specification is:

Maximum torque for pump casing screws:
PVDF M10: 100Ncm

12. Insert the pump casing to the motor by placing the bottom of the pump head on the side of the protecting cup and move it afterwards to the center until the pump-head locks in. Do not directly insert the pump head to the center of the motor as the fingers could be squeezed by the magnetic forces.

CAUTION				
Take care of your fingers. Hold the pump head on the outer side and not on the bottom because of risk to get the fingers squeezed.				



Mount the pump head with the 8 stainless steel screws crosswise and symmetric regular on the Motor. Do not apply too much torque. The torque specification is:

Maximum torque for pump motor screws:
PTFE coated stainless steel M10: 120Ncm

14. Start the system and check if the impeller is rotating properly and the pump head doesn't leak.

15. If the pump head leaks, check and make sure that the lid and the O-Ring are properly pressed into the bottom of the pump casing. It may be necessary to change the O-Ring if it has been damaged.

7 Troubleshooting

7.1 Troubleshooting for Operation with Controller LPC-4000.1

For troubleshooting and failure analysis with the stand-alone controller *LPC-4000.1* the following procedure is recommended:

- Check the status of the LEDs. The specific LEDs are described in *Table 7*
- Use the ERROR codes on the display. The specific error codes are described in *Table 11*
- A digital output on the "USER INTERFACE" connector ("Status") indicates if the system is active. However, the source of an error cannot be identified by this signal

7.2 Troubleshooting for Operation with Controller LPC-4000.2

The integrated *PLC* provides a Warning and an Error signals according to *Table 12*. However, the source of error cannot be identified by these signals.

For more detailed analysis the *Levitronix® Service Software* can be used with a PC and a USB interface to the controller.

7.3 Troubleshooting with Service Software

The *Levitronix® Service Software* allows communication with the pump system in connection with a PC and a USB interface. The software can be used for performing detailed troubleshooting. For usage of the Service Software refer to the *Service Software User Manual* (Document #: *PL-2034-00*), which is available in the download section on the Levitronix Web-page or contact the *Levitronix® Technical Service Department* (see under *Section 8*).

Note: the Service Software can not be used with the standalone controller *LPC-4000.1*.

8 Technical Support

For troubleshooting, support and detailed technical information contact *Levitronix® Technical Service Department*:

Levitronix®
Technical Service Department
Technoparkstr. 1
CH-8005 Zurich
Switzerland

Phone for US: 888-569 07 18
Phone for outside US: +1 888-569 07 18
E-Mail: support@levitronix.com

9 Appendix

9.1 Regulatory Status

9.1.1 CE Marking

The *Bearingless Centrifugal Pump System BPS-4000*, in its various configurations, is in conformity with the essential requirements of the *Machinery Directive 2006/42/EC* (according to Annex II under A) and the essential requirements of the *Low Voltage Directive 2006/95/EC*.

The following particular harmonized standards of the *EMC Directive 2004/108/EC* are tested and confirmed at a certified laboratory (Hochschule für Technik Zurich, Technoparkstr.1, CH-8005 Zürich, Swiss Certification No.: STS404):

EN61000-6-2	Generic standards, Immunity for industrial environments
EN61000-6-4	Generic standards, Emission standard for industrial environments

Additionally the following standards have been used as a guideline for the design and validation:

EN61010-1	Safety requirements for electrical equipment: used as general design guide for controller and motor.
EN60990	Procedure for measurements of leakage currents: measured according to picture 4.
EN809	Pumps for Fluids: basic requirements are followed.
EN12162	Procedure for hydrostatic pressure testing in fluid pumps: max. pressure testing.

9.1.2 ATEX Marking

Specific motors together with the pump head of the *BPS-4000* pump system are in conformity with the requirements of the *Directive 94/9/EC*. The following standards are tested and confirmed at a certified laboratory (Electrosuisse, Switzerland, CH-8320 Fehraltorf, Swiss testing No. STS 001, conformity statement SEV 10 ATEX 0131).

EN60079-0	Electrical apparatus for explosive gas atmospheres. General requirements.
EN60079-15	Electrical Apparatus for explosive gas atmospheres. Construction, test and marking of type of protection, “n” electrical apparatus.
EN61241-0	Electrical apparatus for use in the presence of combustible dust. General requirements
EN61241-1	Electrical apparatus for use in the presence of combustible dust. Protection by enclosure tD

The Levitronix Ex motors are marked clearly and in accordance to the ATEX Directive. The protection EX nA means non sparking electrical apparatus.

CE Ex II 3G Ex nA IIC T5
II 3D Ex tD A22 IP67 T100°C

Classification:	*Category 3GD* (*Zone 2 for Gas* and *Zone 22 for Dust)*
Explosion Groups:	*Group IIA: Propane (IPA), Methane, Aceton, Acetaldehyde* *Group IIB: Ethylene, Ethylenglycol* *Group IIC: Acetylene, Hydrogen (not carbon disulphide*)
Thermal Classification:	Thermal classification of motor is T5 (< 100 ^{0}C = 212 ^{0}F) for maximum full-load operating temperature at a maximum liquid temperature of 90^{0}C / 194 ^{0}F.
UL Correspondence:	*ATEX* listing corresponds to UL hazardous location *Class 1 Division 2*.

9.2 Symbols and Signal Words

Symbol / Signal Word	Description	Type	Source
DANGER	Indication of an imminently hazardous situation that, if not avoided, will result in death or severe injury. Limited to the most extreme situation	Signal word	SEMI S1-0701
WARNING	Indication of a potentially hazardous situation which, if not avoided, could result in death or severe injury.	Signal word	SEMI S1-0701
CAUTION	Indication of potentially hazardous situations which, if not avoided, could result in moderate or minor injury. Also alert against unsafe practice. Without safety alert indication of hazardous situation which, if not avoided, could result in property damage.	Signal word	SEMI S1-0701
	Safety alert for “Warning” and “Caution”	Safety alert	SEMI S1-0701
	Safety alert for “Danger”	Safety alert	SEMI S1-0701
	Caution (refer to accompanying documents) (is used on article labels for reference to manual)	Refer to manual	ISO 3864
	Toxic material, poison	Hazard identification	IEC 61310
	Corrosive material, corrosion	Hazard identification	IEC 61310
	Cut/sever hand, sharp object	Hazard identification	ANSI Z535.3
	Strong magnetic field	Hazard identification	SEMI S1-0701
	Danger: electricity, electrical hazard	Hazard identification	IEC 61310, ISO 3864
	Wear safety gloves	Hazard avoidance Mandatory action	IEC 61310
	Wear face shield	Hazard avoidance Mandatory action	SEMI S1-0701
	Unplug power line	Hazard avoidance Mandatory action	SEMI S1-0701
	No pacemakers	Hazard avoidance Prohibition	SEMI S1-0701
	ATEX Logo	Used for hazard identificat. in warnings	--

Table 13: Safety symbols and signal words